

# Integrated science



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# Chapter 1: Environmental Resources



In this chapter, we will study the following topics:

**1 Energy Transfer in Ecosystems**

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**2 Preserving Environmental Resources**

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## Chapter One

### Lesson 1: Energy Transfer in Ecosystems

#### Get Ready!

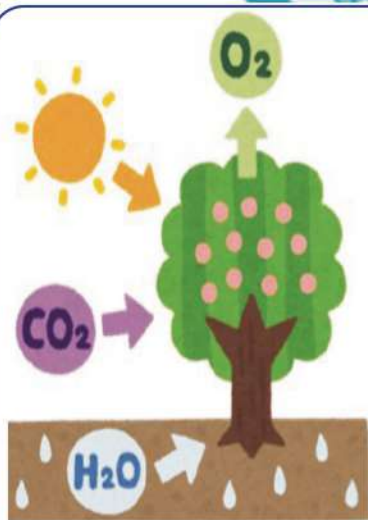
Imagine yourself in the heart of a dense forest, under the bright sunlight, where plants sparkle with vibrant green hues as they absorb sunlight. But how do these plants become a source of food for the animals living there?

#### What We will learn in this lesson

We will explore how energy from the sun flows through ecosystems via food chains and how this process impacts ecological balance. Using concepts from physics and chemistry, we'll understand how energy transfers and the effects of this transfer on living organisms in the environment.

#### The Concept of Energy in an Ecosystem

One way to study the interaction between living organisms in ecosystems is by tracing the transfer of energy within the system.



A plant gets its food (energy) from photosynthesis



Snake preys on a mouse



A fungus gets its nourishment (energy) from a dead tree trunk

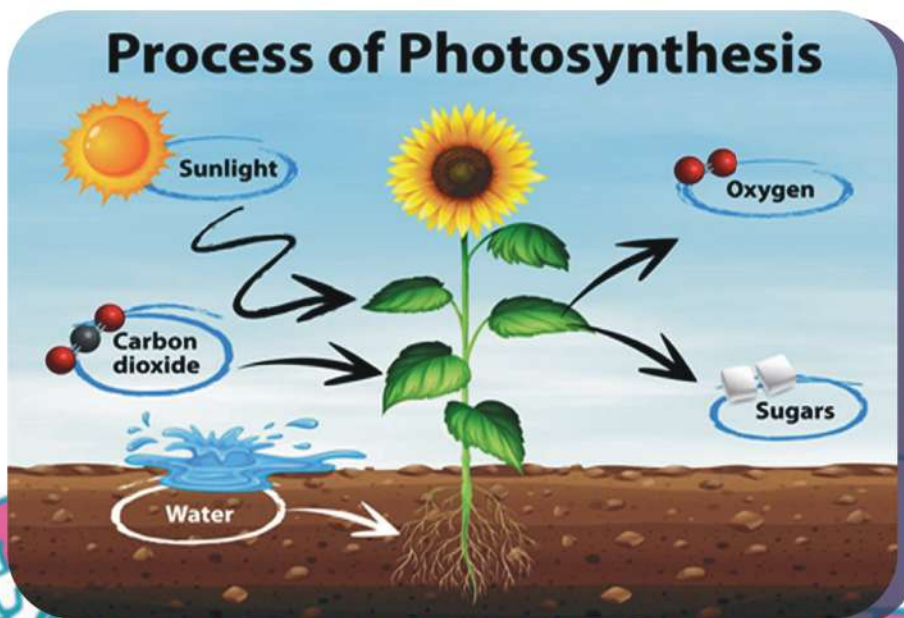






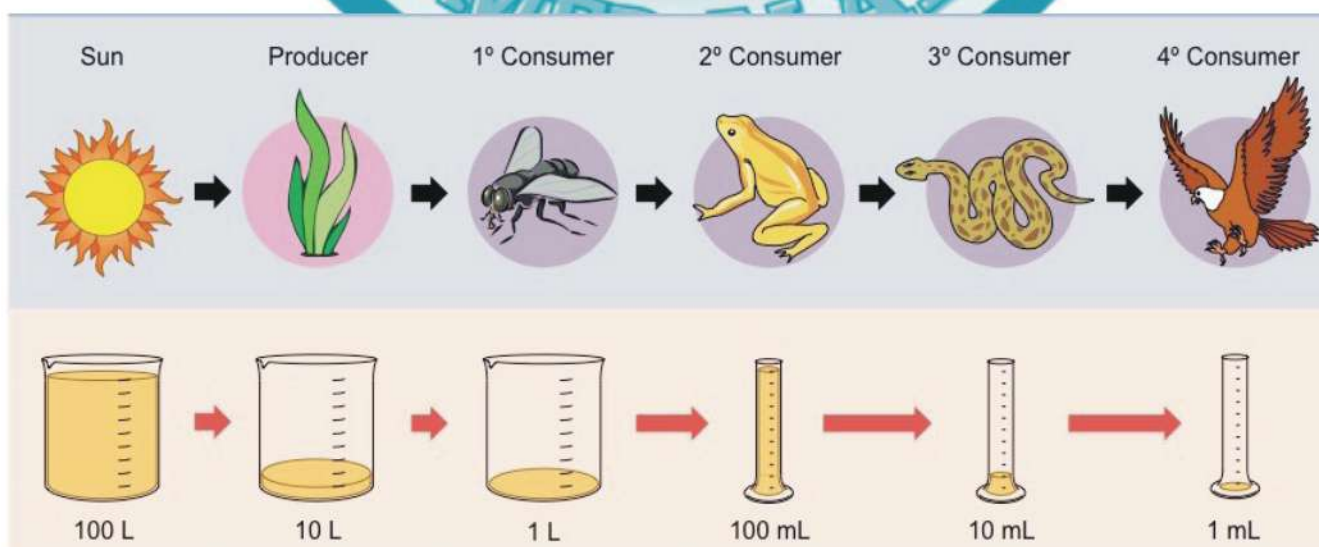
## Energy Transfer

When sunlight reaches plants, they perform photosynthesis. During this process, plants convert solar energy into chemical energy stored in sugar molecules within them.



## Energy Transfer Through Food Chains

When insects feed on plants, they obtain the chemical energy stored in the plants sugars. This energy is transferred from the plant to the insect, and then, when another animal feeds on the insect, the energy is transferred from the insect to the animal. With each transfer of energy between trophic levels, a significant amount of energy is lost.



Representation of energy flow

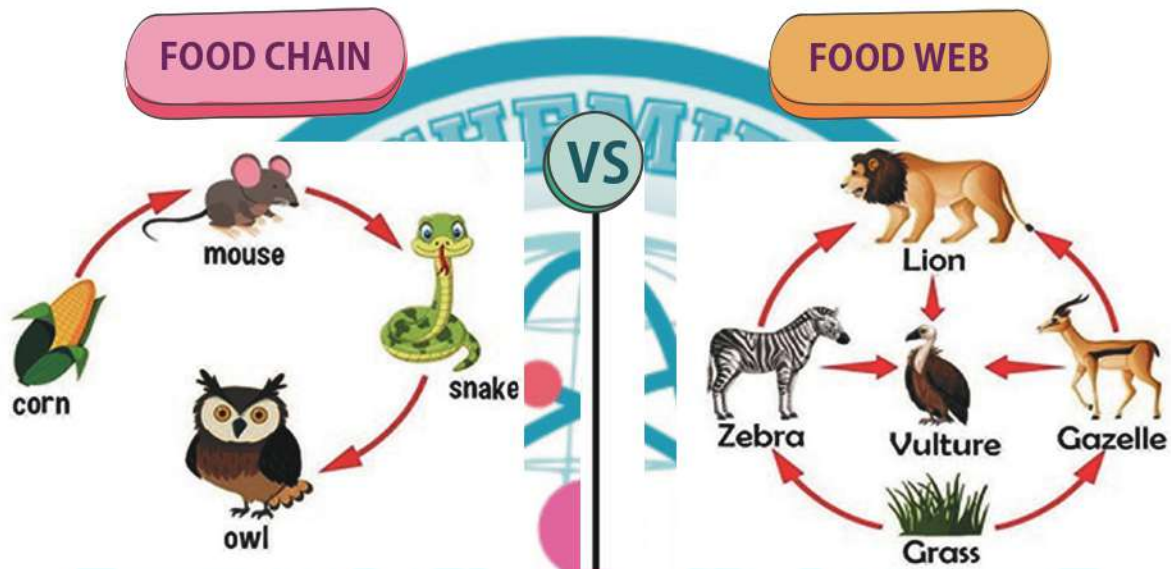






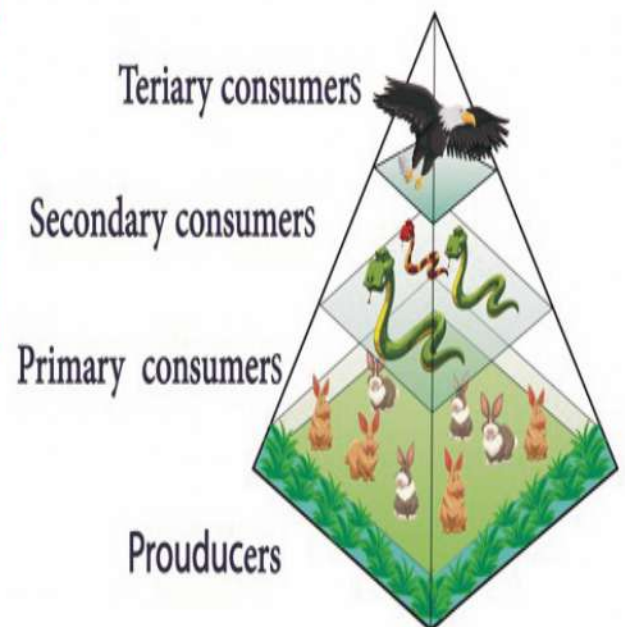
## The role of food chains and food webs

- Ecologists use food chains and food webs as models to illustrate energy transfer within an ecosystem. Each step in the food chain or web is known as a «trophic level.»
- Trophic levels begin with autotrophic organisms, which form the first trophic level in all ecosystems, followed by heterotrophic organisms that make up the subsequent trophic levels.



## Measuring and transferring energy

- The energy transfer pyramid is used to illustrate the number of organisms relying on the same energy source, helping to determine the efficiency of energy transfer across trophic levels.
- The efficiency of energy transfer is approximately 10% between each level (explain) about 90% of the energy is lost in biological processes such as excretion and respiration, during which the largest amount of glucose (chemical energy) is consumed directly rather than animals that feed on plants.
- Due to the significant energy loss, energy pyramids rarely contain more than six levels, as the remaining energy becomes insufficient to sustain another organism. Therefore, it is preferable for humans to consume plants







## Calculating the lost energy

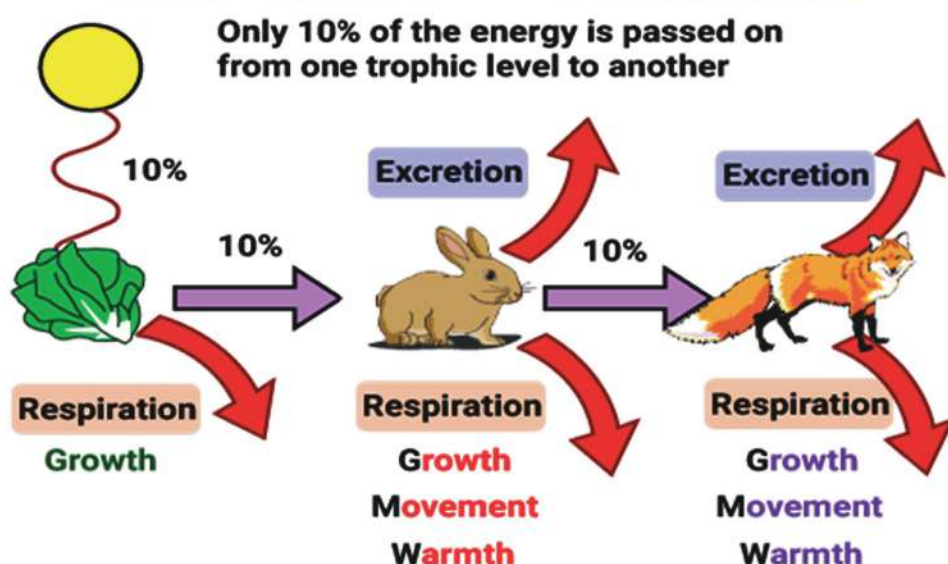
Lost energy is the energy not directly used in biological processes, and this does not contradict the law of conservation of energy; part of an organism's energy is lost as heat during respiration and other biological activities.

### Illustrative Example:

- Suppose a rabbit obtains 100 joules (J) of energy from consuming plants. The energy is distributed as follows:
  - 1 The majority is used during cellular respiration, where sugar is converted into carbon dioxide (**chemical energy**) and returned to the environment during exhalation.
  - 2 Another portion is converted into **kinetic energy**, enabling the rabbit to move.
  - 3 A portion is transformed into **thermal energy** to keep the body warm. A small amount of energy remains in undigested food (**chemical energy**), which is expelled as waste and returned to the soil through excretion.
- When adding up these different forms of energy, we find that their total is 100 joules (J), which aligns with the law of conservation of energy.

### Lost energy:

It is simply the energy not used directly, representing the difference between the total energy from food and the energy utilized by the organism for essential processes such as movement and growth.







### Scientific Activity !!!!!!!!!

Suppose a plant receives 1000 joules (J) of solar energy and uses only %2 of this energy in the process of photosynthesis, while the rest is lost as heat, reflection, or absorption in other parts. Calculate:

- ① The amount of energy the plant uses in photosynthesis.
- ② The amount of energy that was lost.

## Conservation of Energy

### Conservation of Energy in Food Chains

1

The law of conservation of energy is clearly demonstrated in food chains through the transformation of energy into various forms. The chain begins with solar energy from the sun, which is converted within plants into chemical energy stored in food during the process of photosynthesis.

2

This energy is then transferred to the **primary consumer** when it feeds on the plant. During this stage, the chemical energy undergoes conversion into thermal and kinetic energy through respiration, with some energy lost as heat.

3

When energy is transferred to the **secondary consumer**, which feeds on the **primary consumer**, additional energy loss occurs during processes such as respiration and excretion.

4

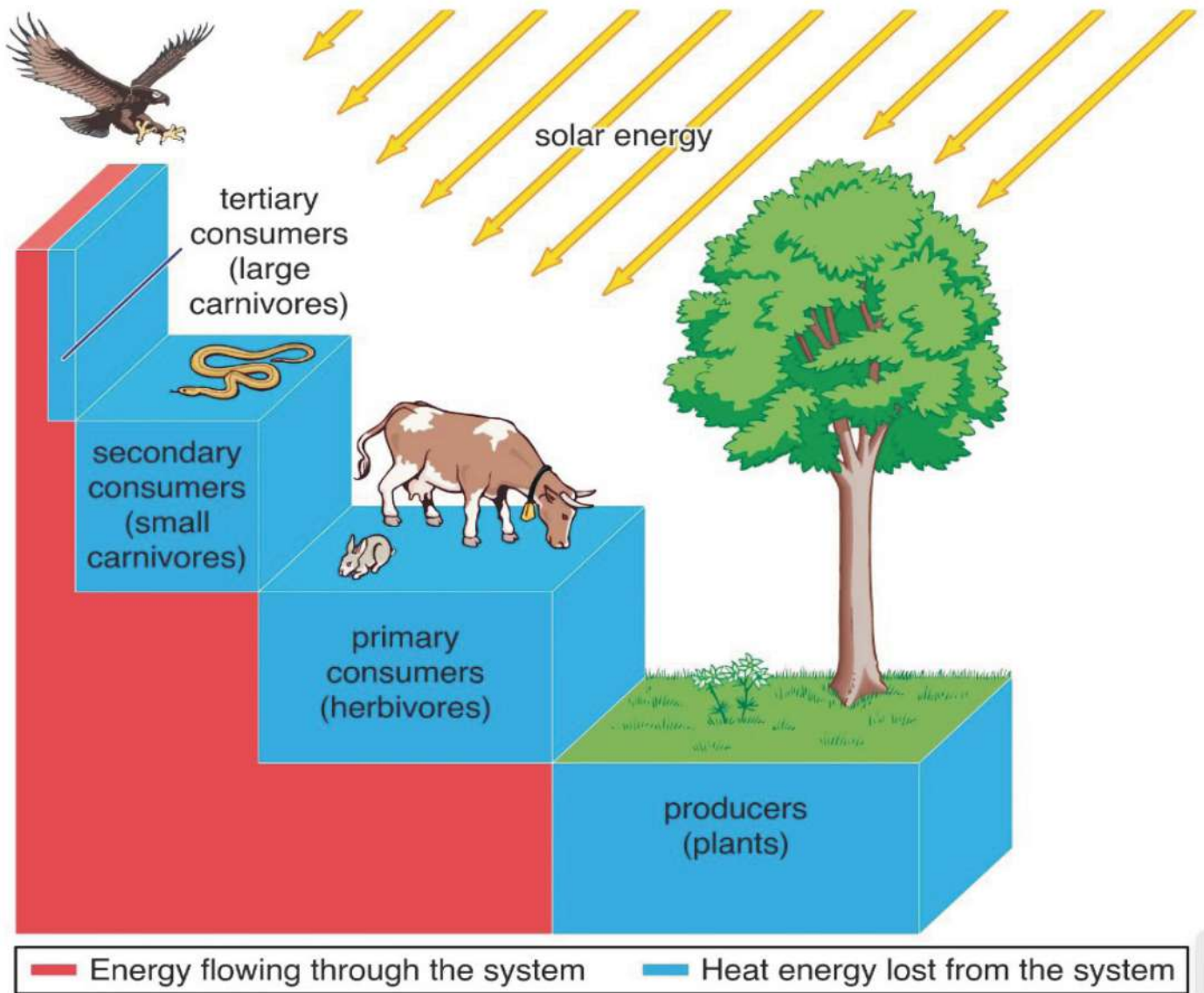
These energy transformations continue until the remaining chemical energy in the **decomposed organisms** is recycled into the soil by decomposers in the form of nutrients.

5

Throughout the food chain, energy is lost at each level in the form of heat. However, this does not contradict the **law of conservation of energy**, which states that energy cannot be created or destroyed but only transformed from one form to another.

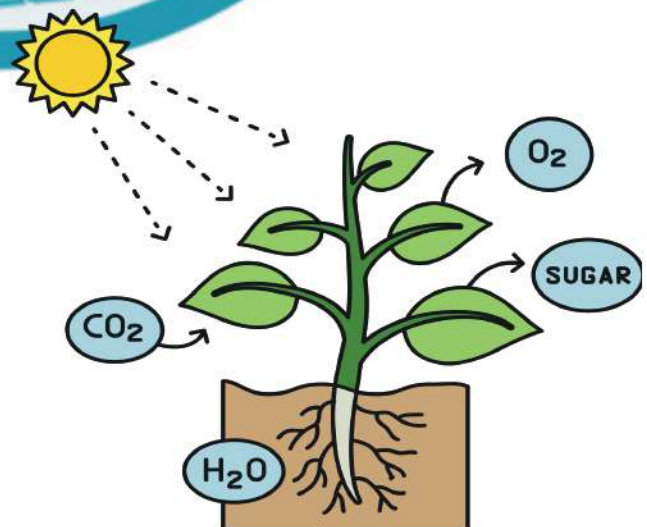






## Chemistry in Energy Transfer

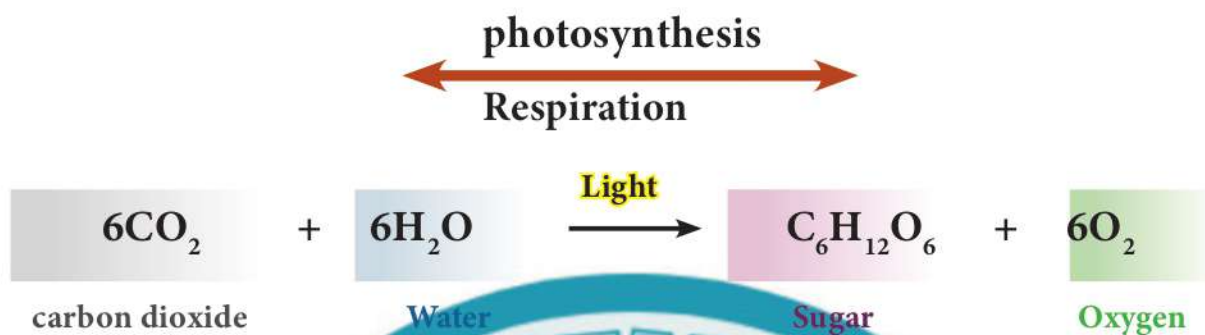
The journey of energy transfer begins within living organisms, starting with green plants. During the process of photosynthesis, which takes place inside the chloroplast (a specialized cellular organelle in plants).







**Complex chemical reactions take place.** The process begins with the absorption of light by chlorophyll, the green pigment in plants. Light stimulates chemical reactions that convert carbon dioxide and water into glucose and oxygen, as illustrated by the following equation:



Chlorophyll

The chemical energy stored in glucose is utilized by other living organisms in the food chain when they feed directly or indirectly on plants. When glucose (a biofuel) is burned with oxygen inside the organisms body during the process of respiration, thermal energy is generated. This energy is essential for sustaining the life of the organism.

Respiration:



Thus, energy is transformed from light energy into chemical energy stored within the chemical bonds of the glucose molecule, and then into thermal energy, which contributes to the survival of living organisms.

## The energy stored within fossil fuels

### Formation and Utilization of Fossil Fuels:

#### Formation of Fossil Fuels:

Fossil fuels such as coal, petroleum, and natural gas are formed from living organisms that stored solar energy either directly or indirectly.

#### Coal:

Composed primarily of carbon (C), coal is formed from the remains of decomposed trees and plants buried deep within the Earth millions of years ago.







## Petroleum:

Petroleum is a mixture of various hydrocarbon compounds. It originates from marine organisms and plants buried millions of years ago, decomposing under high pressure and temperature.

## Natural Gas:

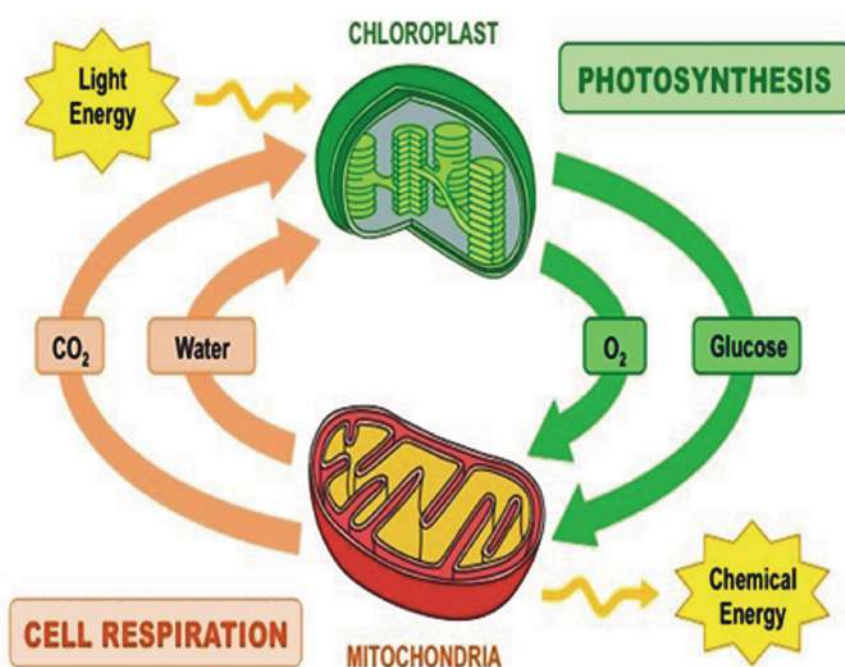
Natural gas consists of a mixture of hydrocarbon gases, primarily methane (98–70%), with small amounts of ethane, propane, and butane. It is found floating above petroleum deposits underground, within coal mines, or trapped between rock layers.

## Utilization:

When fossil fuels are burned with oxygen, such as in internal combustion engines, thermal energy is generated. This energy drives the operation of machines and is vital for their functionality.

## The Relationship Between Photosynthesis and Cellular Respiration

- These reactions help maintain the balance of oxygen and carbon dioxide in the atmosphere. Plants produce oxygen and store energy in glucose.
- Meanwhile, other living organisms (such as animals and humans) consume oxygen and use glucose to produce energy, releasing carbon dioxide and water as waste products.







## The Impact of the Relationship Between Photosynthesis and Cellular Respiration on the Ecosystem

### 1. Ecological Balance

- The relationship between photosynthesis and cellular respiration contributes to maintaining the balance of gases in the atmosphere. Plants produce oxygen and capture carbon dioxide during photosynthesis.
- Meanwhile, other living organisms consume oxygen and produce carbon dioxide during respiration, helping to maintain the ecological balance.

### 2. Energy Flow

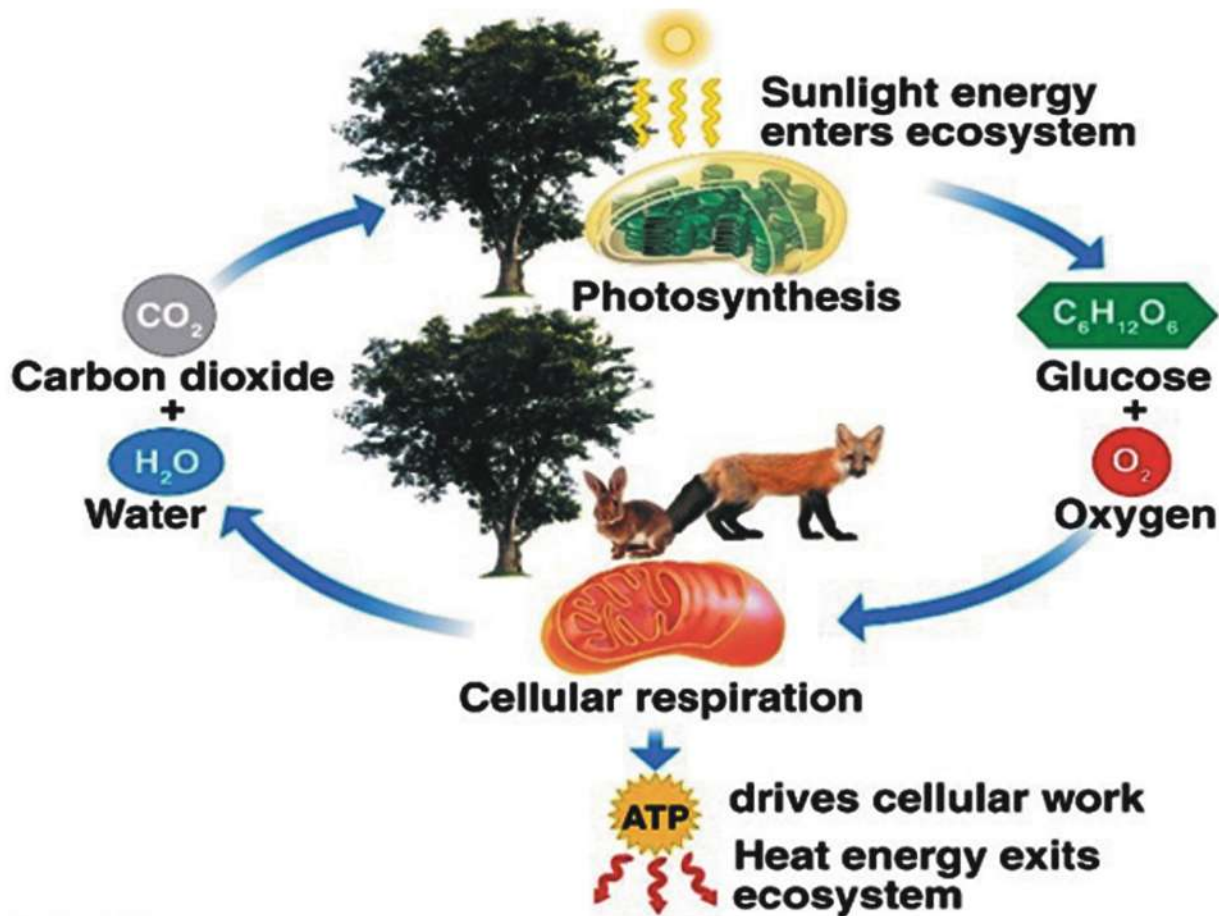
- The solar energy stored in glucose molecules through photosynthesis is transferred through the food chain when plants are consumed by animals.
- This energy is used in cellular respiration to produce ATP (adenosine triphosphate), the primary energy source for all vital processes in living organisms.

### 3. The Carbon Cycle

- Photosynthesis and cellular respiration both contribute to the natural carbon cycle, where carbon dioxide and water are recycled between the environment and living organisms.
- Simply put, photosynthesis provides glucose and oxygen, which are used in cellular respiration to release energy. This integration between photosynthesis and cellular respiration ensures the flow of energy and the balance of gases in the ecosystem, supporting life on Earth.







## Research and Investigation

### Practical Experiment: Exploring Photosynthesis

#### Materials Required:

1

An aquatic plant, such as Elodea

2

A transparent bottle or glass cup & water

3

Baking soda (sodium bicarbonate)

4

Aluminum foil or opaque paper

5

A flashlight or light source (e.g., sunlight)

6

Paper and pens for note-taking







## Steps:

### 1 Prepare the Plant:

Fill the bottle or glass cup with water.

- Add a small amount of baking soda (about half a teaspoon) to the water to increase the
- carbon dioxide level, which is essential for photosynthesis.
- Place the aquatic plant in the water and allow it to adjust for a few minutes.

### 2 Set Up the Light:

- If you're using a flashlight, direct the light toward the plant.
- If you're using sunlight, place the plant in a sunny spot.

### 3 Cover the Parts:

To identify the areas where photosynthesis occurs, cover some of the plants leaves with aluminum foil or opaque paper. Leave other leaves exposed to sunlight or artificial light.

### 4 Observe the Reaction:

Place the plant under the light and leave it for several hours. After the period has passed, remove the aluminum foil or opaque paper. Observe any changes in the exposed leaves compared to the covered ones.

### 5 Oxygen Test:

You can conduct a simple test for the presence of oxygen. Fill the glass cup with water, then place the plant in it. Wait for some time and observe the air bubbles that may form on the surface of the water. These bubbles are the result of oxygen production during photosynthesis.

### 6 Analysis and Interpretation:

Compare the results between the exposed and covered leaves. Observe where the most bubbles were produced—exposed leaves should produce more oxygen than the covered ones, indicating that photosynthesis occurs in the exposed leaves. Write your observations about how light affects the photosynthesis process.







## Chapter One

### Lesson 2: Preserving Environmental Resources

#### Get Ready!!!

Have you ever wondered how daily activities like driving cars or using household chemicals affect the environment? In this lesson, we will explore how human activities impact environmental resources and how we can preserve them by applying principles of chemistry, physics, and life sciences. We will discover how these scientific concepts can help us develop effective strategies for environmental conservation.

#### Learn

**Efficiency of Systems in Energy Conversion:** This refers to the efficiency of a system in converting an undesirable form of energy into a more desirable one. More efficient systems minimize the production of unwanted energy, thereby reducing energy consumption rates.

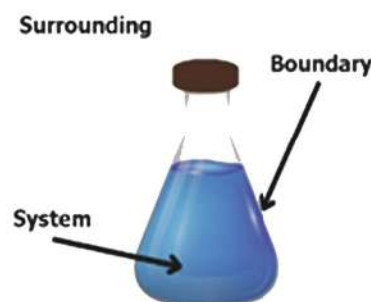
### Key Concepts in Thermodynamics

Thermodynamics is the branch of science that studies energy and its transformations during physical, chemical, and biological processes. **The core concepts include:**

#### 1 System

The system is the part of the universe under study, whether it involves a chemical, physical, or biological process.

**Example:** When mixing hydrochloric acid with sodium hydroxide solution, this mixture is considered the system



#### 2 Surroundings:

The surroundings are the environment around the system that can interact with it by exchanging energy in the form of heat or work. The surroundings can be real or hypothetical.







## 3 System Boundary:

This is the barrier that separates the system from its surroundings, controlling the exchange of energy and matter.

**Example:** The walls of a glass beaker containing a chemical solution act as the systems boundary.

## Types of Systems in Thermodynamics

Feature	Open System	Closed System	Isolated System
Definition	A system that exchanges both energy and matter with its surroundings.	A system that exchanges only energy (not matter) with its surroundings.	A system that does not exchange energy or matter with its surroundings.
Matter Exchange	Possible	Not possible	Not possible
Energy Exchange	Possible	Possible	Not possible
Example	Boiling water in an open pot	Water in a sealed, insulated bottle	A perfectly insulated thermos flask (theoretical)
System Boundary	Allows the flow of both energy and matter	Allows the flow of energy only	Prevents the flow of both energy and matter
Interaction with Surroundings	Strong interaction	Limited interaction	No interaction
Represented Shape	<p>OPEN</p>		
	<p>CLOSED</p>		
	<p>ISOLATED</p>		







## System Properties

⇒ The physical properties of a system can be divided into two main groups:

### 1 Extensive Properties:

These properties depend on the amount of matter present in the system.

**Examples:** Mass, volume, heat capacity, internal energy, surface area.

### 2 Intensive Properties:

These are characteristic properties of the material and are independent of the amount of matter.

**Examples:** Temperature, density, surface tension, specific heat.

## Thermodynamics Laws

The laws of thermodynamics explain physical processes, chemical reactions, and biological processes related to energy transformations.

### The First Law of Thermodynamics

States that energy cannot be created or destroyed but only transformed from one form to another.

#### ● Mathematical Expression:

$$\Delta U = \Delta Q - \Delta W$$

#### ● Where:

- $\Delta U$ : Change in internal energy of the system.
- $\Delta Q$ : Heat added to or removed from the system.
- $\Delta W$ : Work done by or on the system.







## Notes:

- 1 **Internal Energy ( $\Delta U$ ):** The total of the kinetic energy of molecules and the potential energy resulting from the forces of attraction between them.
- 2 **Change in Internal Energy** occurs when:
  - i. Heat ( $\Delta Q$ ) is transferred to or from the system.
  - ii. Work ( $\Delta W$ ) is done by or on the system.
- 3  **$\Delta Q$**  is positive when heat is absorbed by the system and negative when heat is released.
- 4  **$\Delta W$**  is positive when work is done by the system and negative when work is done on the system.
- 5 Thermodynamic Processes can be classified into three categories:
  - a. **Adiabatic Process**
    - No heat transfer ( $\Delta Q=0$ ).
    - Relation:  $\Delta U = -\Delta W$ .
    - **Example:** Rapid compression of gas.
  - b. **Isothermal Process**
    - Constant temperature ( $\Delta U=0$ ).
    - Relation:  $\Delta Q = \Delta W$ .
    - **Example:** Melting ice or boiling water at a constant temperature.
  - c. **Isochoric Process**
    - Constant volume ( $\Delta W=0$ ).
    - Relation:  $\Delta Q = \Delta U$ .
    - **Example:** Heating water in a sealed container.

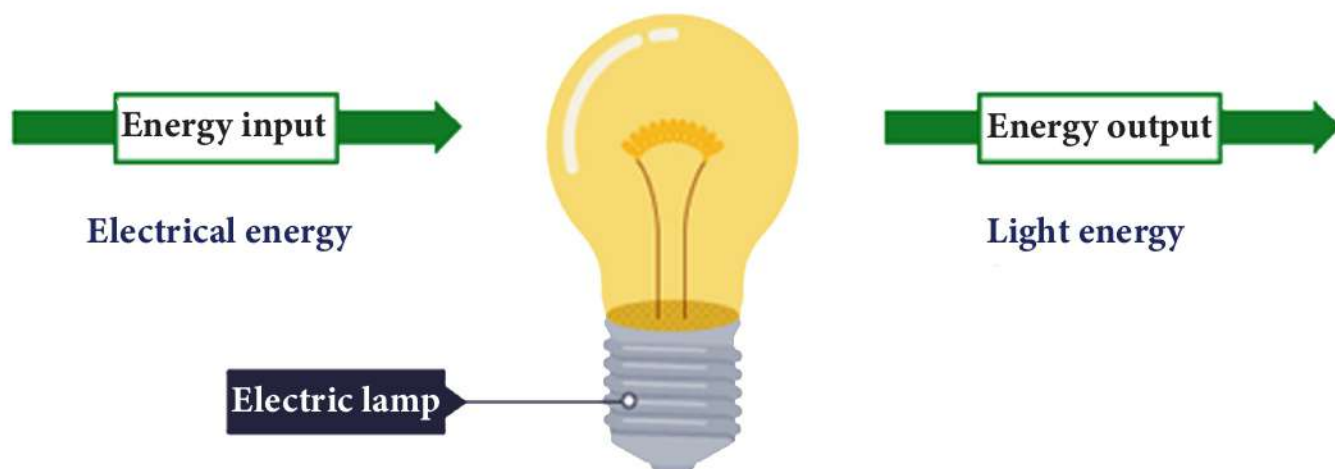
## Examples of the First Law of Thermodynamics

### 1 Electric Light Bulb

- When an electric bulb is turned on, electrical energy from the source is converted into **thermal energy** and **light energy**.
- This process exemplifies energy transformation from one form to another, while the total energy remains constant in accordance with the **First Law of Thermodynamics**.

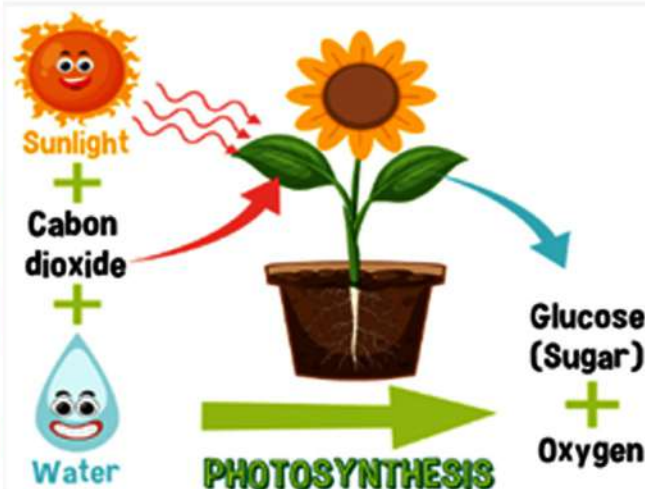






## 2 Photosynthesis Process

- Plants absorb light energy from the sun and convert it into chemical energy stored in organic compounds, releasing oxygen as a byproduct.
- This chemical energy transfers to herbivores when they consume plants, and later to carnivores as they eat herbivores. Throughout this energy transfer chain, heat is gained and lost, but the total energy remains constant according to the First Law.



## 3 Physical Example (Gas in a Cylinder)

- If a gas is compressed slowly in a cylinder to half its original volume while maintaining a constant temperature, the internal energy of the system does not change ( $\Delta U=0$ ).
- According to the First Law of Thermodynamics, the heat transferred to the gas equals the work done on the gas during compression.

### Energy Transformation Efficiency and Energy Conservation

- The efficiency of energy processes refers to the proportion of useful energy transferred between different levels compared to the input energy.







**Example:** In an ecosystem, as energy transitions from one level to another (e.g., the conversion of light energy in plants into kinetic energy in animals), a portion of the energy is lost as heat at each stage, reducing the transfer efficiency. Despite these losses, the total energy in the system remains constant, as guaranteed by the first law of thermodynamics.

### Example:

In a cylinder, the gas volume is reduced to half its original size very slowly, and during this process, the temperature remains constant. The work done in compression is 45 J.

### Calculate:

- ① The change in the internal energy of the system.
- ② The amount of heat transferred to the gas.

$$\Delta U = \Delta Q - \Delta W \Rightarrow 0 = \Delta Q - \Delta W$$

$$\Delta Q = \Delta W \Rightarrow \Delta Q = \Delta W = 45 \text{ Joule}$$

## Research and Investigation

Using reliable research sources, analyze a physical process, a chemical process, or a biological process in one of the living organisms in the context of the principles and laws of thermodynamics.

## Chemistry and Energy

### The Relationship Between Chemical Reactions and Energy Conservation

**Chemical reactions** are represented using chemical equations, where reactants are transformed into products.

The quantity of reactants and products is measured in **moles**.

**Mole:** The molecular, atomic, or formula unit mass of a substance expressed in grams.

**For example:** The mass of one mole of water ( $\text{H}_2\text{O}$ ) is 18 g.



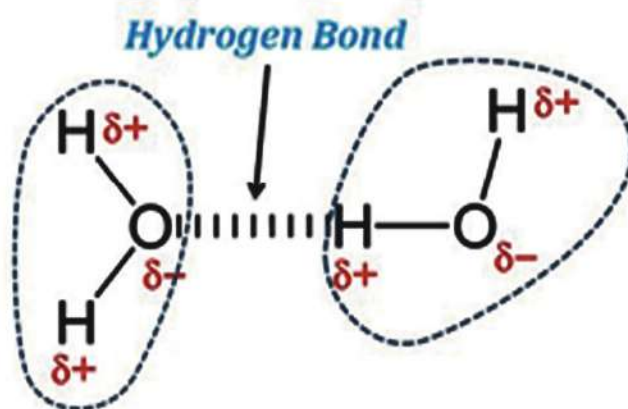
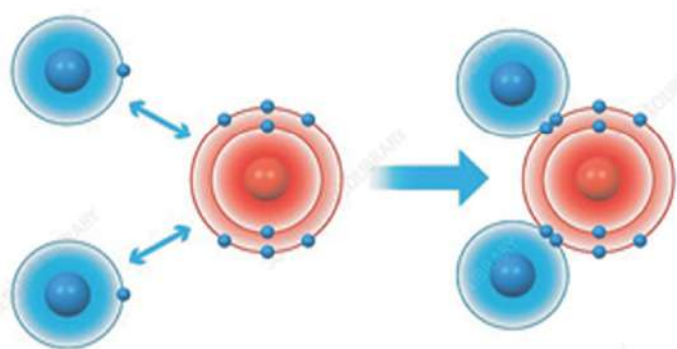




## Enthalpy (H):

The chemical energy stored in one mole of a substance, which consists of the total energy in:

- 1 Individual atoms:** Representing the potential and kinetic energy of electrons in energy levels.
- 2 Within molecules:** Found in the chemical bonds (ionic or covalent) connecting atoms.
- 3 Between molecules:** Found in intermolecular forces, such as hydrogen bonds and Van der Waals forces.



## The change in enthalpy ( $\Delta H$ )

Represents the difference between the total enthalpy of the products and that of the reactants:

$$\Delta H = H_{\text{products}} - H_{\text{reactants}}$$

### 1. Exothermic Reactions:

- Reactions that release heat to the surroundings, increasing the temperature of the environment.
- The enthalpy of the reactants is higher than that of the products.
- The enthalpy change ( $\Delta H$ ) is negative. **Example:** The formation of water.

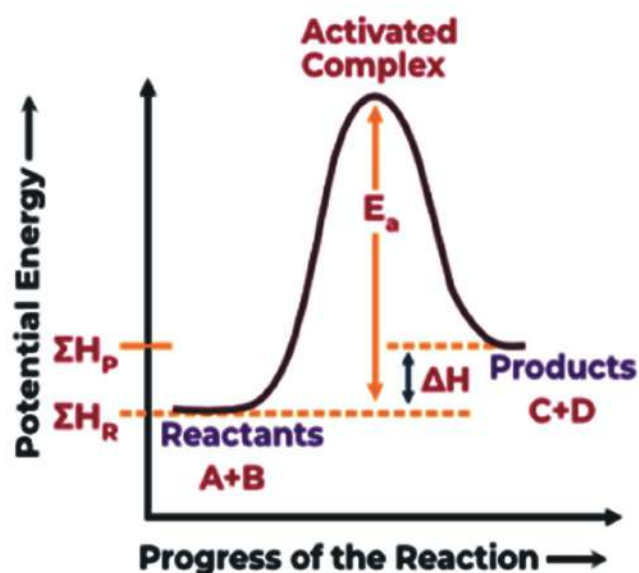
### Types of Chemical Reactions Based on Enthalpy Change

### 2. Endothermic Reactions:

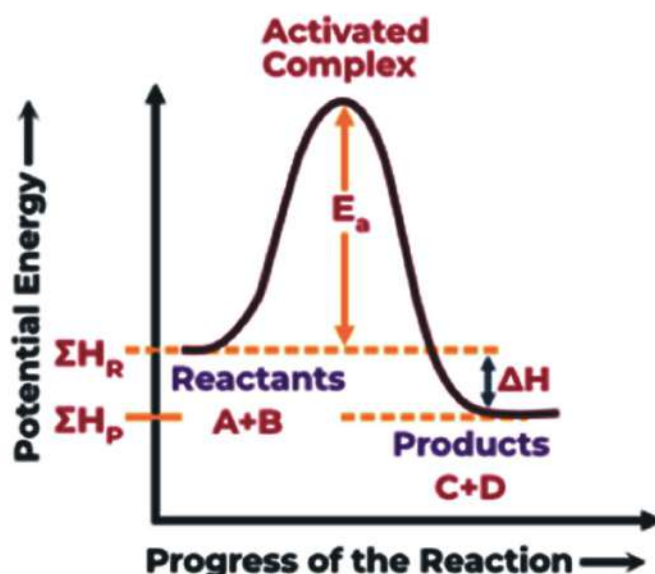
- Reactions that absorb heat from the surroundings, lowering the temperature of the environment.
- The enthalpy of the reactants is lower than that of the products.
- The enthalpy change ( $\Delta H$ ) is positive.
- Example: The decomposition of magnesium carbonate.







**Endothermic Reaction**



**Exothermic Reaction**

## Units of heat measurement

- Here is a table comparing different units of heat measurement:

Joule (J)	Calories (cal)
The amount of heat energy required to raise the temperature of 1 gram (1 g) of pure water by 4.184 / 1 °C	The amount of heat energy required to raise the temperature of 1 gram (1 g) of pure water by 1 °C, from 15 °C to 16 °C.

Formula J - > cal

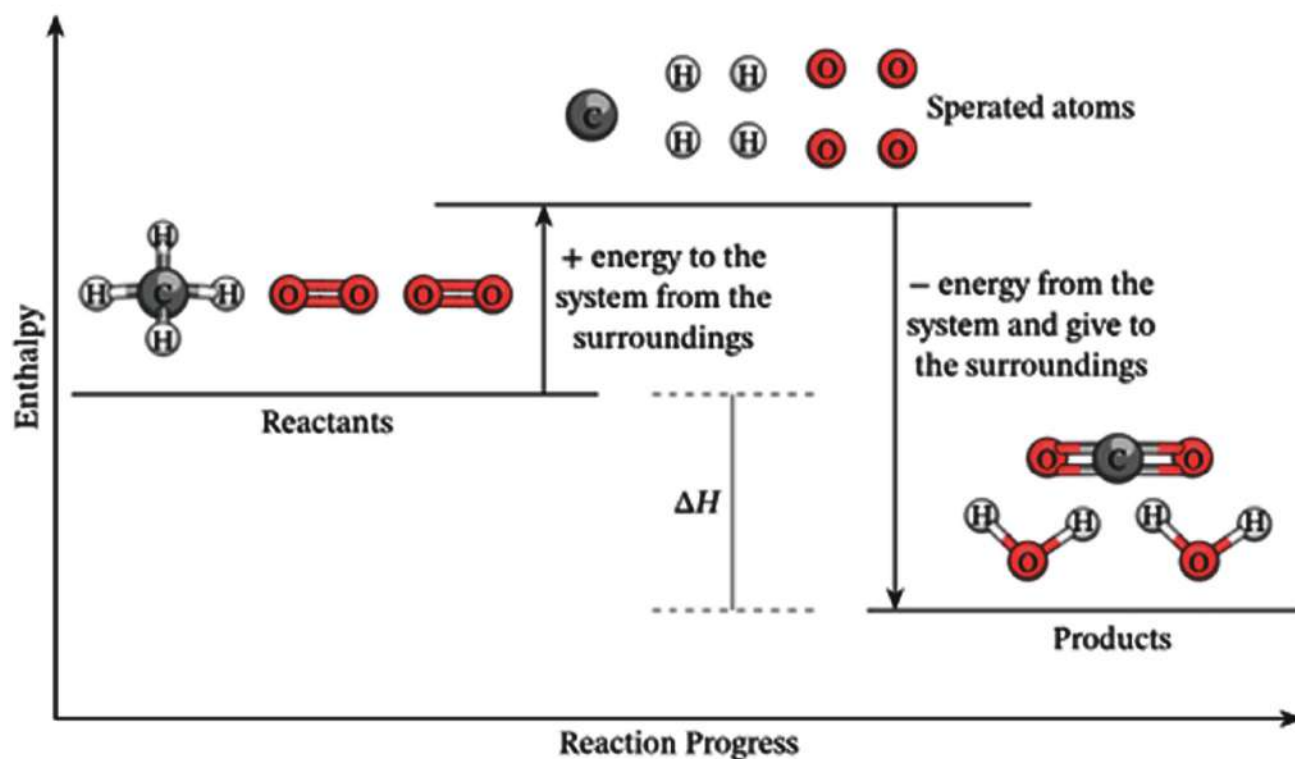
$$\text{Cal} = \frac{\text{J}}{4.187}$$

## Why is a chemical reaction accompanied by a heat change?

- To determine the type of heat change in a chemical reaction, we need to know the energy required to break or form bonds in one mole of the substance.
- If the energy released during the formation of the bonds in the products is greater than the energy absorbed to break the bonds in the reactants, the reaction is exothermic, and **ΔH is negative**. If the energy absorbed to break the bonds in the reactants is greater than the energy released during the formation of the bonds in the products, the reaction is endothermic, and **ΔH is positive**.







## Task:

Analyze a study on the impact of thermodynamics on the efficiency of energy transformations in an ecosystem.

## Research and Investigation

Available data: An experiment was conducted on two plants of the same species during the same growth period. One plant was exposed to a light source of 2000 lux, while the other was exposed to a light source of 1000 lux. The growth of the two plants was measured after two weeks.

Plant	Under 2000 Lux Light (Plant A)	Under 1000 Lux Light (Plant B)
Final height	30 cm	20 cm
Final mass	100 g	60 g
Water used	2 liters	2 liters

**Discussion:** Based on the table data, how can you compare the efficiency of energy transformations between Plant A and Plant B? Use the First Law of Thermodynamics to explain how light affects growth and stored energy.







## Chapter One

### Lesson 3: Nutrients and the Health of Ecosystems

#### Get Ready!!!

- Have you ever wondered how plants and animals stay healthy in their environments? The health of ecosystems relies on a delicate balance of nutrients that cycle through nature in complex ways.
- In this lesson, we will explore how these cycles work and how human activities impact them. By understanding the role of nutrients in ecosystems, you can learn how human actions influence the environment and how to maintain its balance.

#### Learn

In ecosystems, nutrients act as essential components that sustain the life of living organisms. They are crucial for the growth, development, and health of plants and animals, playing a vital role in biological processes. These nutrients include carbon, nitrogen, and phosphorus, each with a specific role in supporting ecosystems.

### Types of Major Nutrients

#### 1 Carbon (C):

Carbon is a fundamental element in all organic compounds, including **carbohydrates, proteins, lipids, and nucleic acids** (RNA and DNA). It exists in various forms:

- |   |  |  |
|---|--|--|
| <b>1</b> <b>Atmosphere:</b> as carbon dioxide gas ( $\text{CO}_2$ ).          | <b>2</b> <b>Living Organisms:</b> in terrestrial and marine organisms.   | <b>3</b> <b>Soil:</b> in organic matter and humus.           |
| <b>4</b> <b>Water:</b> as carbonate and bicarbonate salts ( $\text{HCO}_3$ ). | <b>5</b> <b>Rocks:</b> in forms such as limestone ( $\text{CaCO}_3$ ) and dolomite ( $\text{CaMg}(\text{CO}_3)_2$ ). | <b>6</b> <b>Fossil Fuels:</b> in coal, oil, and natural gas. |







## The Carbon Cycle

The carbon cycle is a continuous biological and geological process that exchanges carbon among living organisms, the atmosphere, water, and rocks.

### Photosynthesis:

The cycle begins when green plants absorb carbon dioxide from the atmosphere during photosynthesis to produce organic compounds. Carbon dioxide is then returned to the atmosphere through plant respiration.

### Herbivores:

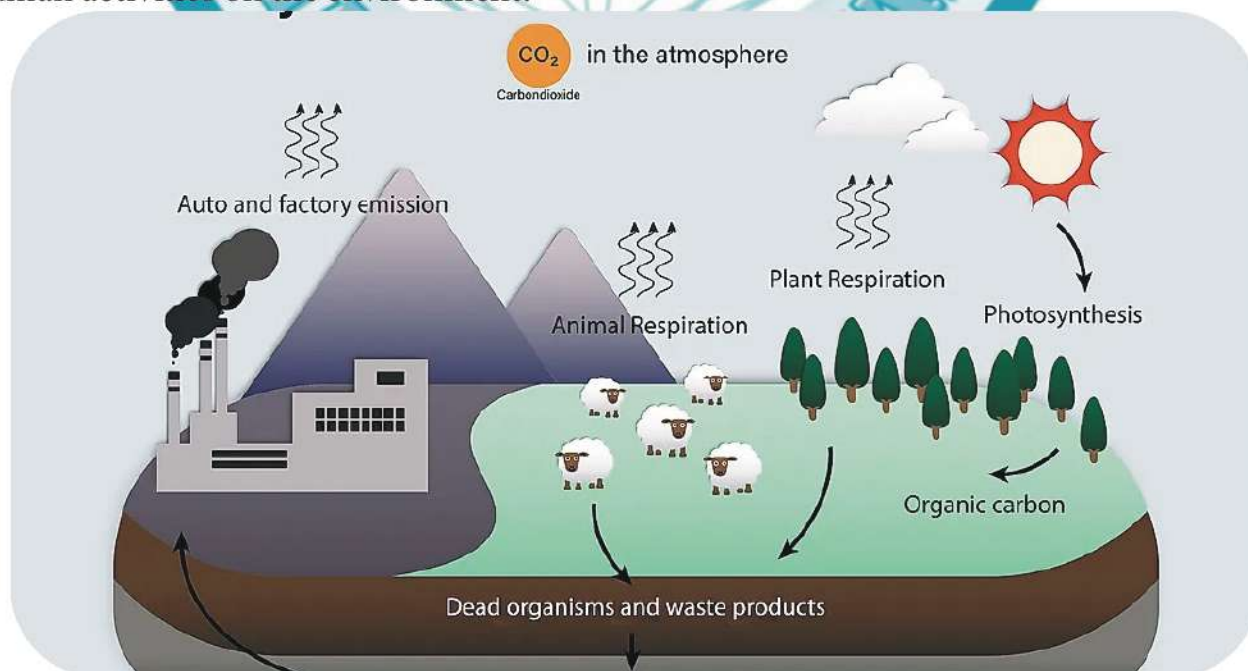
When herbivores consume plants, carbon moves into their bodies, becoming part of their tissues and cells. It is released back into the atmosphere through respiration, waste, or decomposition after death.

### Oceans and Rocks:

A portion of dissolved  $\text{CO}_2$  in oceans forms calcium carbonate, stabilizing carbon in limestone over time. Carbon is also released back into the atmosphere through the burning of fossil fuels.

### Significance:

The carbon cycle is complex and essential for understanding climate change and the impact of human activities on the environment.

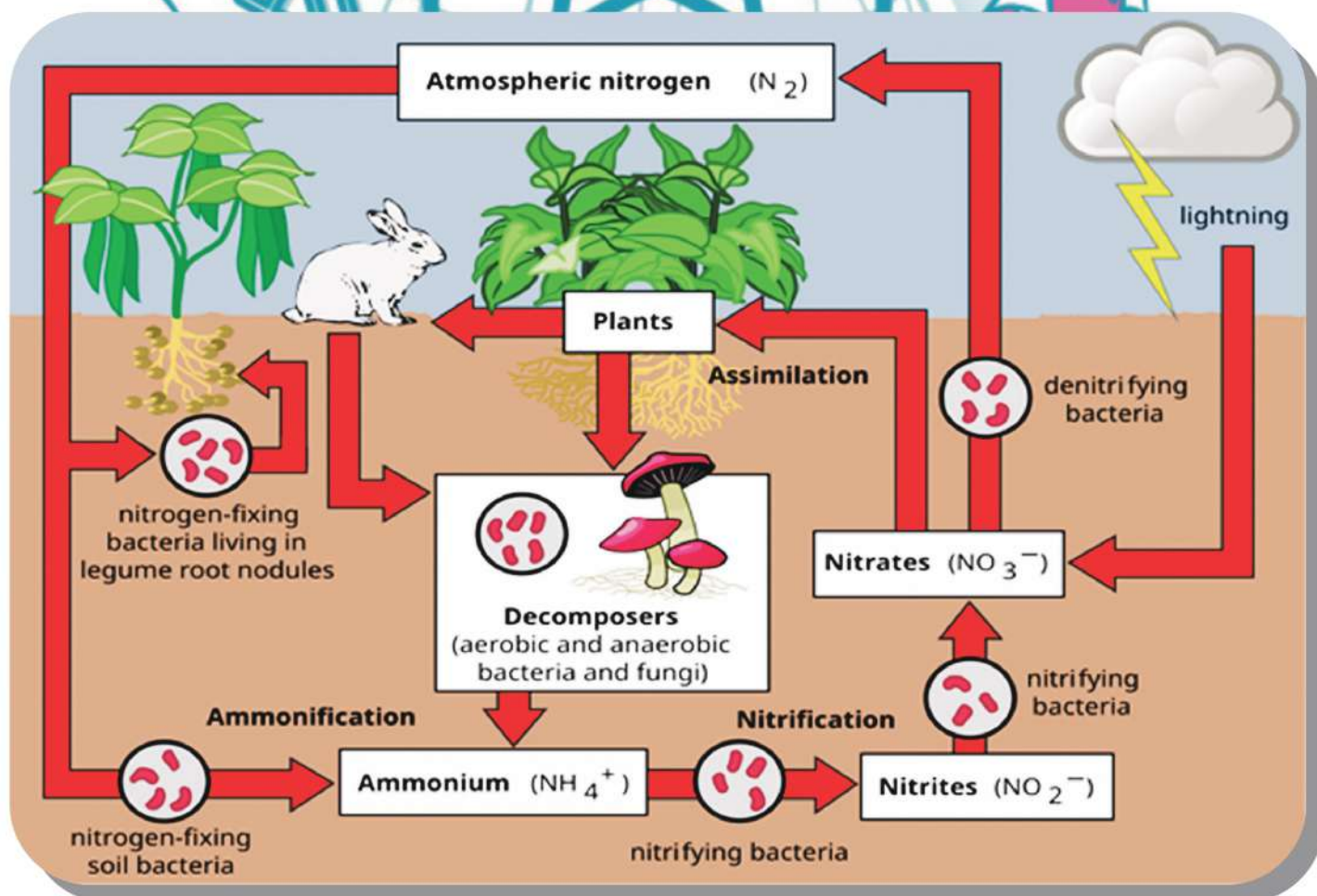






## 2 The Nitrogen

- **Importance of Nitrogen:** Nitrogen is a key element in proteins, which are essential for the growth and development of organisms.
- **Nitrogen Fixation:** Certain bacteria convert nitrogen from the air into ammonia ( $\text{NH}_3$ ), allowing plants to absorb nitrogen and build proteins.
- **Nitrogen Transformation:** Ammonia is converted into nitrites ( $\text{NO}_2^-$ ) and nitrates ( $\text{NO}_3^-$ ) by nitrifying bacteria. Plants utilize these nitrates, while animals obtain nitrogen through their diet.
- **Nitrogen Recycling:** Denitrifying bacteria return some nitrogen to the atmosphere as  $\text{N}_2$  gas or nitrous oxide.
- **Human Impact:** Nitrogen-based fertilizers are widely used in agriculture, but excessive use can lead to groundwater contamination.





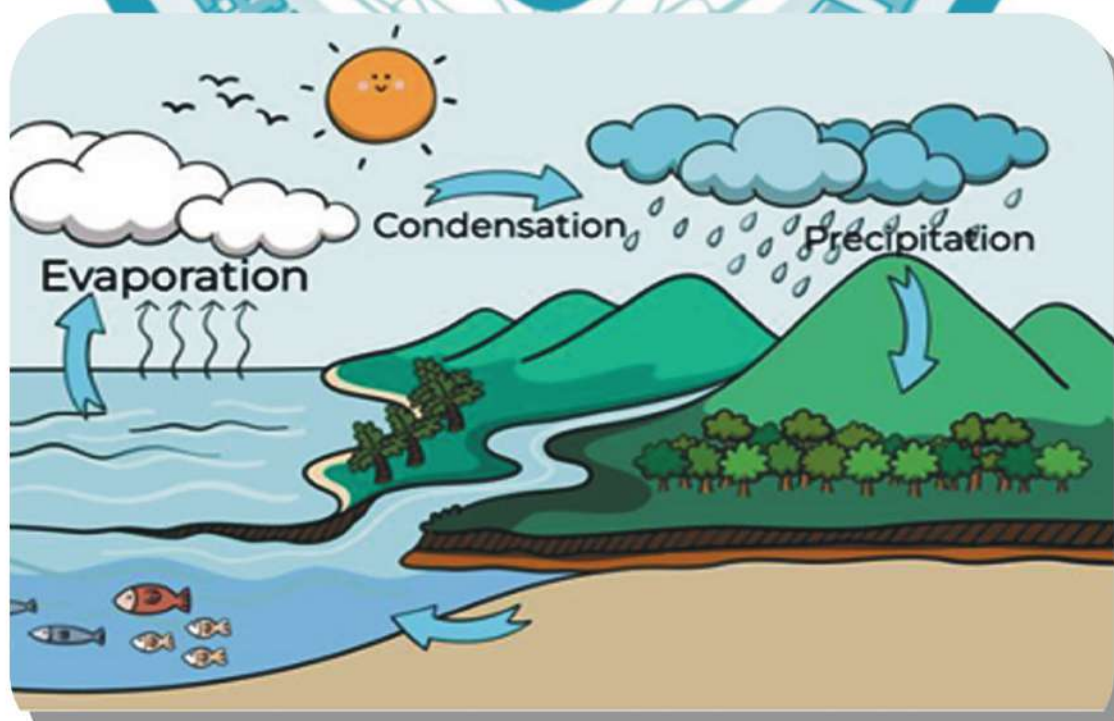


### 3 Phosphorus:

- **Importance of Phosphorus:** Phosphorus plays a vital role in energy storage and transfer within cells (ATP). It also contributes to the development of roots, flowers, and fruits in plants.
- **Sources:** Phosphorus is found in rocks and minerals. It dissolves in water, allowing plants to absorb it, and it then moves through the food chain.
- **Significance to Ecosystems:** Phosphorus supports living organisms, including plants and nitrates, and helps maintain ecological balance.

#### Impact of Physical Processes

- **Rainfall and Evaporation:** Rainfall influences the transport of nutrients into the soil, while evaporation facilitates the movement of water into the atmosphere.
- **Effect of Drought:** Drought reduces the concentration of organic carbon and nitrogen while increasing the concentration of inorganic phosphorus, negatively impacting ecological balance.
- **Summary:** The cycles of carbon, nitrogen, and phosphorus are essential for supporting life. Understanding their roles helps in promoting the sustainability of ecosystems and mitigating the negative effects of human activities.







## Research and Investigation

- **Scenario:** You are a researcher working at a specialized water quality research center. You received a report from an agricultural area indicating a nitrate contamination issue caused by excessive use of fertilizers. The report highlights changes in the health of aquatic plants and animals due to this pollution.
- **Objective:** Analyze how nitrate pollution affects the nutrient cycle in a freshwater ecosystem and its impact on plant health and other living organisms.

### Task:

Analyze the impact of nitrate pollution on water quality and plant health using pre-collected experimental data and results.

Location	Nitrate Concentration (mg/L)	Plant Growth Percentage (%)	Dissolved Oxygen Level (mg/L)	Aquatic Organisms Health
Site 1 (near agricultural land)	50	40%	2.5	Severely Affected
Site 2 (mid-river)	30	60%	4.5	Mildly Affected
Site 3 (clean water source)	10	90%	7.0	Normal

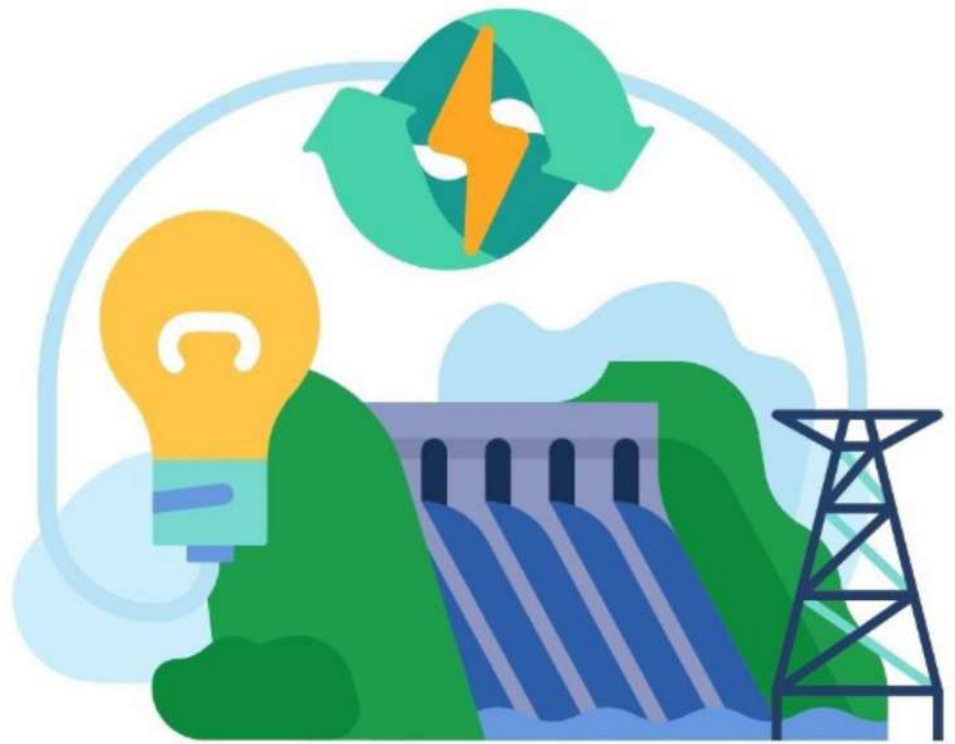
### Questions for Analysis:

- 1 **Comparison of Water Quality and Plant Health:** Based on the provided data, how does nitrate contamination affect water quality in the location compared to Site 3? How does this reflect on plant health and growth in these areas?
- 2 **Nitrate Concentration and Dissolved Oxygen Relationship:** What is the relationship between nitrate concentration and the reduction in dissolved oxygen levels in water? How does this impact the health of aquatic animals?
- 3 **Impact on Nutrient Cycling:** How does nitrate pollution affect the natural nutrient cycling in the freshwater ecosystem? Explain this through its effects on plants and aquatic organisms.
- 4 **Long-Term Consequences:** If nitrate pollution continues at this rate, what are the potential long-term outcomes for this area? What might happen to the biodiversity in the aquatic system?
- 5 **Mitigation Strategies:** Based on the data and your analysis, what actions can be taken to reduce nitrate pollution and improve water quality at Site 1?





# Chapter 2: Renewable and Non-Renewable Energy



In this chapter, we will study the following topics:

1

**Renewable and Non-Renewable Energy**

29

2

**Chemistry and Mining**

36

3

**Renewable Energy**

40

4

**Applications of Renewable Energy in Daily Life**

45





## Chapter Two

### Lesson 1: Renewable and Non-Renewable Energy

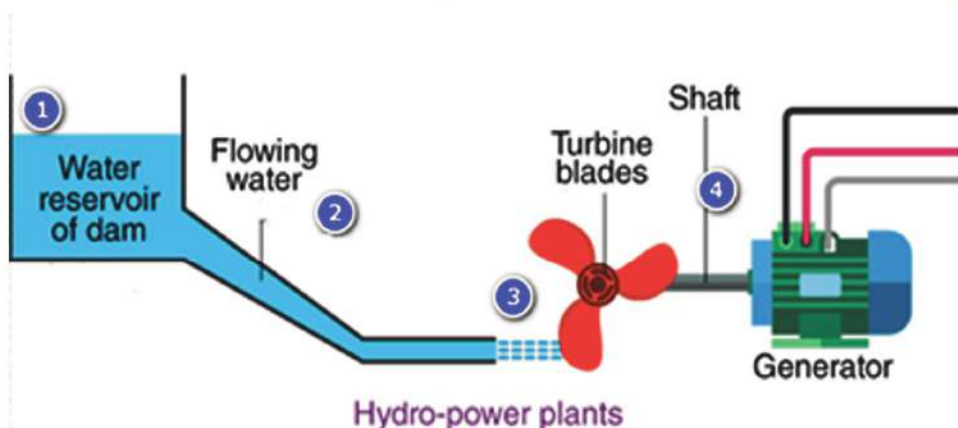
#### Get Ready!!!

- Energy drives the wheel of life and is used in various fields such as food, sports, and electricity. However, in the context of science and engineering, energy refers to the ability to do work or cause change. Energy transforms from one form to another, and it is neither created nor destroyed.
- Modern life relies on energy sources such as coal, oil, and natural gas, which power homes, vehicles, and provide electricity. However, excessive use of these resources can lead to significant environmental impacts. **In this lesson**, we will explore fossil fuels, how energy is produced from them, and their environmental effects.

#### Forms of Energy

Natural sciences have been concerned for centuries with studying matter and energy as fundamental concepts. Energy exists in various forms, each of which can transform into another. **For instance**, light, thermal radiation from the sun, chemical energy, nuclear energy, electrical energy, mechanical energy, and others are all forms of energy.

The figure illustrates a model of a hydroelectric power plant. Explore four forms of energy arranged according to their transformations, and identify the output energy of the plant.







## Energy Sources

- 1 Renewable Energy Sources
- 2 Non renewable Energy Sources

### ► First: Renewable Energy Sources

- Energy sources extracted from the Earth that take millions of years to form, meaning they are consumed much faster than they can renew.
- When these sources are depleted, they cannot be replaced quickly enough to meet human needs. Common examples include coal, oil, and natural gas.

### 1 Oil (Petroleum)

#### Definition:

A mixture of hydrocarbons extracted from the depths of the earth.

#### Uses:

Includes powering cars, airplanes, and factories, as well as manufacturing plastics and chemical products.

#### Environmental Impact:

Burning petroleum releases greenhouse gases such as carbon dioxide ( $\text{CO}_2$ ), contributing to global warming and climate change.

#### Example:

Oil spills from tankers threaten marine life and pollute oceans.







## 2 Coal

### Definition:

A fossil fuel formed from decomposed plant remains over millions of years.

### Uses:

Primarily used for electricity generation and powering factories.

### Environmental Impact:

One of the most polluting energy sources, releasing large amounts of carbon dioxide and sulfur, which contribute to climate change and air pollution.

### Example:

Open-pit coal mines destroy natural habitats and contribute to the extinction of certain plant and animal species.



## 3 Natural Gas

### Definition:

A mixture of flammable gases extracted from beneath the earth's surface.

### Uses:

Used for cooking, heating homes, and generating electricity.

### Environmental Impact:

Cleaner than oil and coal, but its combustion releases carbon dioxide and water vapor.

### Example:

Gas leaks from pipelines can pollute the environment and increase the risk of explosions.



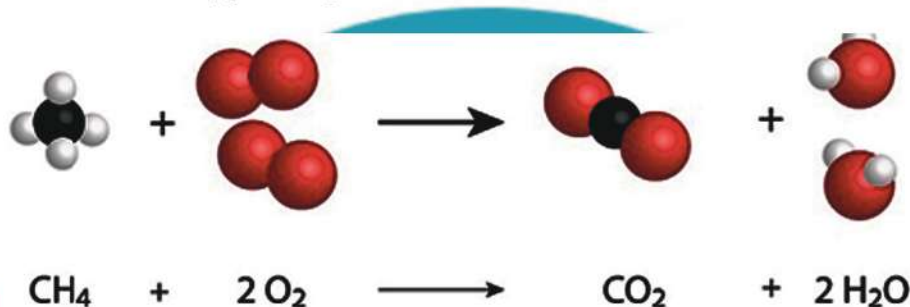




## The most important gases and air pollutants produced by burning fossil fuels

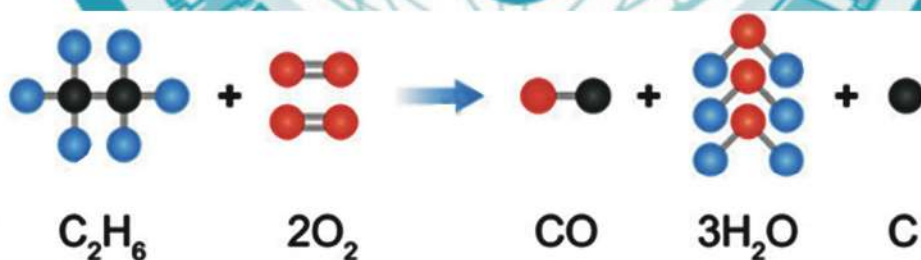
### 1 Carbon dOxides:

Produced from the combustion of hydrocarbons in fossil fuels, such as methane gas. Carbon and hydrogen react with oxygen to produce carbon dioxide and water.



### 2 Carbon Monoxide (CO)

- **Properties:** A toxic, colorless, and odorless gas.
- **Formation:** Produced from the incomplete combustion of carbon-based fuels, such as wood and gasoline.
- **Impact:** Affects the human body by interfering with oxygen transport in the blood, causing severe symptoms such as difficulty breathing, fatigue, and potentially leading to death.



### 3 Nitrogen Oxides (NO and NO<sub>2</sub>)

- **Formation:** Produced during the combustion of fossil fuels at high temperatures, where nitrogen impurities react with oxygen to form nitrogen oxides, such as nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>).
- **Harmful Effects:** Cause respiratory irritation and contribute to cardiovascular diseases.







## 4 Sulfur Oxides (SO<sub>x</sub>)

- **Formation:** Produced from the combustion of fuels containing sulfur impurities. Sulfur dioxide (SO<sub>2</sub>) is formed and further oxidized in the air to produce sulfur trioxide (SO<sub>3</sub>).

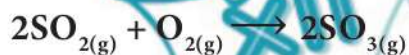
- **Environmental Impact of Sulfur Oxides:**

### o Acid Rain Formation:

SO<sub>3</sub> reacts with water in the atmosphere to form sulfuric acid (H<sub>2</sub>SO<sub>4</sub>), a major component of acid rain.

o **Damage to Cultural Heritage:** Acid rain corrodes buildings and stone monuments, especially those made of calcium carbonate. The reaction with acid rain produces calcium sulfate, which is more soluble in water than calcium carbonate, leading to erosion and damage to cultural and historical artifacts.

- The above reactions are represented by the following equations:



## Role of Chemicals and Pollutants

- **Industrial Activities:** Activities such as chemical production and the use of fertilizers and pesticides release toxic substances into the environment.
- **Fossil Fuel Combustion:** Sulfur dioxide and nitrogen oxides released from burning fossil fuels contribute to the formation of acid rain, polluting soil and water.

## Energy Production from Fossil Fuels

### Electric Power Generation Process:

The process of converting energy from one form to another varies depending on the energy source and the technologies used.

### Importance of Electric Power Generation:

Essential for supplying homes and businesses with energy to operate electrical devices.

### Support by Electric Power Systems:

Electrical power systems support economic growth, create job opportunities in the energy sector, improve quality of life, and enhance economic and national security.







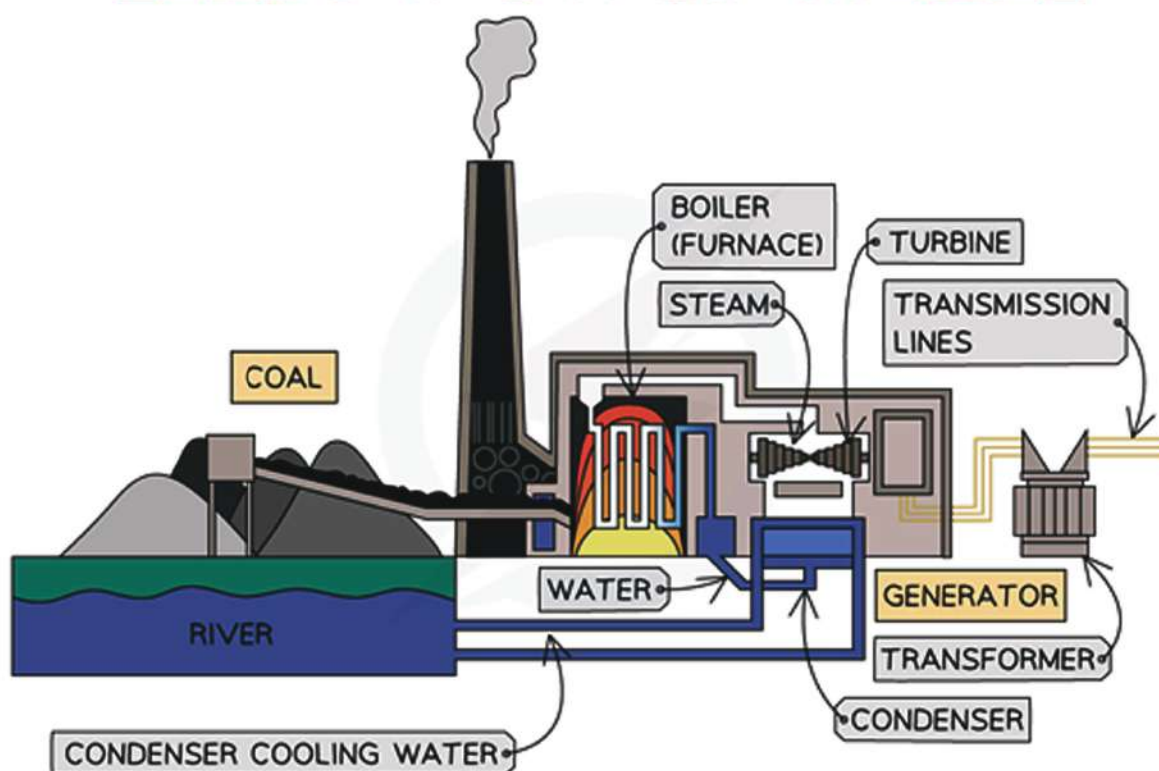
## Power Plants

- The energy generation process relies on the First Law of **Thermodynamics**.
- The chemical energy stored in fossil fuels is converted into electrical energy.
- Power plants consume large amounts of fossil fuels and produce significant quantities of gases, such as carbon dioxide, which contribute to global warming and the greenhouse effect.



## How a Power Plant Works

- Power plants use various types of fuel (such as coal, oil, or natural gas) to generate thermal energy.
- A certain amount of fuel is burned to heat water and convert it into steam. The steam then moves to turbines, where it operates under pressure, converting kinetic energy into electrical energy.
- A significant amount of energy is lost as heat or in the form of carbon dioxide, which affects both the plants efficiency and the environment.







## Research and Investigation

- Conduct a simple experiment to burn different types of fuel (such as candles or small pieces of coal) and observe the resulting products. How might these reactions affect the environment?

- **Required Tools:** (Small candles, small pieces of coal, matches or a lighter, metal plate or heat-resistant surface, small mirror or glass slide (to collect soot), test tube or small glass bottle (to collect gases))

### Steps of the Experiment:

- • Choose a well-ventilated area to perform the experiment and follow the safety instructions provided by the teacher.
- Place the candles and coal pieces on the metal plate or heat-resistant surface.

### Check Your Observations:

- When burning the candles, you may notice light smoke and black deposits (soot) on the glass slide or mirror. This soot is unburned carbon. In the case of burning coal, you may observe thick smoke with a greater amount of soot accumulating on the glass slide or mirror. You might also notice a strong smell, especially if the coal has a high sulfur content.

**MAKE  
today  
GREAT**







## Chapter Two

### Lesson 2: Chemistry and Mining

#### Get Ready!!!

- Review of natural resources: such as minerals, oil, coal, and others.
- The importance of these resources in meeting daily needs.
- The effects of excessive use on the environment and the importance of managing the resulting waste.

#### Depletion of Natural Resources

- It is the consumption of resources at a rate that exceeds their ability to regenerate.

##### Impacted resources include

fossil fuels, minerals, water, soil, and biodiversity.

##### Impacts include:

ecosystems, public health, and economies.

**Example:** Mining is the process of extracting minerals from the earth.

##### Environmental impacts:

- Removal of soil layers, affecting temperature and humidity.
- Air and water pollution.
- Soil erosion and land degradation.
- Underground mining creates voids that lead to ground collapse or the formation of pits.

##### Other impacts:

- **Land structure change:** Removal of upper layers causes land erosion and destruction of natural habitats.
- **Chemical pollution:** Chemicals may seep into groundwater, altering its physical properties and affecting aquatic environments.







## Chemistry and Mining

Chemistry is linked to the processes of extracting, refining, and using minerals in various industries. This includes:

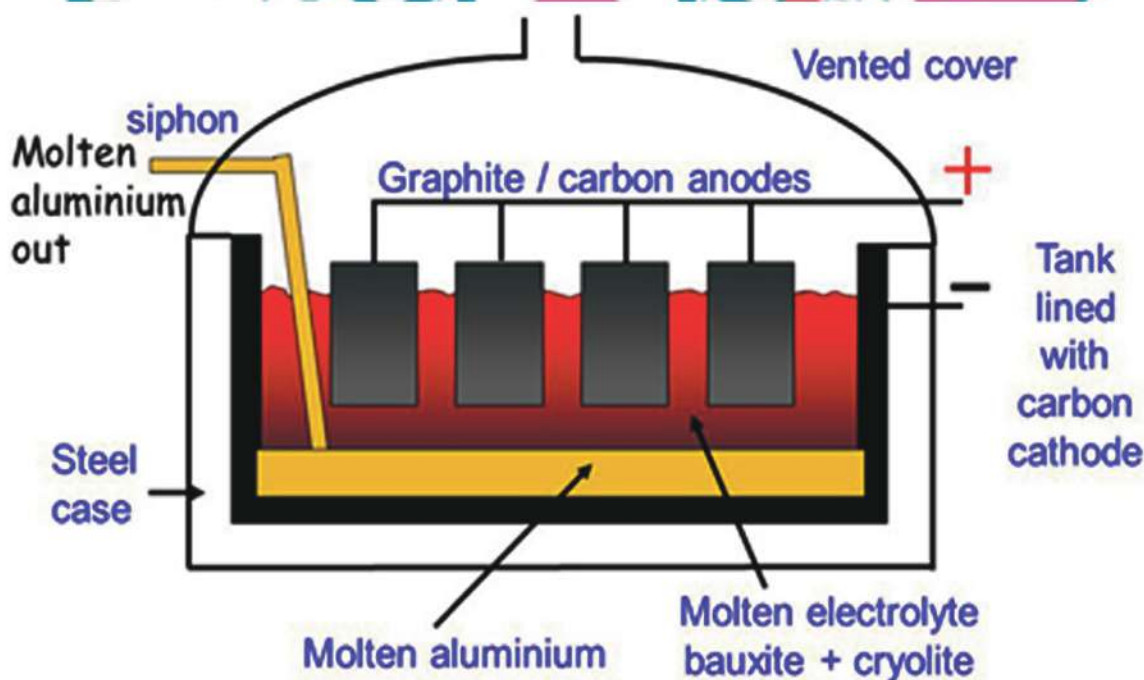
### 1 Chemical analysis of ore

The ore is analyzed using chemical techniques to determine the type and quantity of the mineral, which helps in evaluating the feasibility of the mining process.

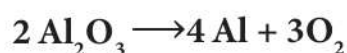
### 2 Extraction of minerals

#### a Extraction of aluminum from bauxite ore:

Aluminum is extracted from bauxite ore ( $\text{Al}_2\text{O}_3$ ) dissolved in cryolite ( $\text{Na}_3\text{AlF}_6$ ) through an electrolytic process in the electrolytic cell as shown in the diagram.



#### • Aluminum extraction equation:

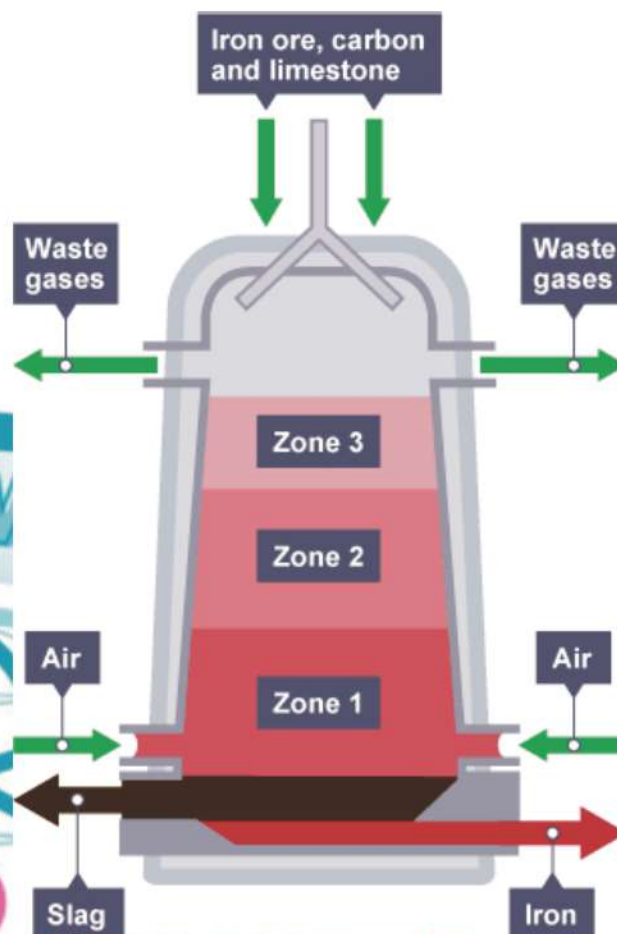






## b Extraction of iron from hematite:

Iron is extracted from hematite ore in a blast furnace using coke, which reacts with oxygen to produce carbon monoxide, the reducing agent that extracts iron in its molten form.



## c Extraction of gold using cyanide:

Cyanide is used to extract gold from its ores by dissolving it in a sodium cyanide solution. Gold is then separated using activated carbon or other methods.

### Gold extraction equation:



## Mineral Purification

After extracting minerals, they need purification processes using electrolysis (such as copper purification) or chemical agents to remove impurities.

## Environment and Mining

Chemistry contributes to reducing the environmental impact of mining by developing methods to treat polluted water and dispose of waste safely.







## Disposal of Chemical Waste

### Classification and Separation:

Waste is classified according to its type and danger level (e.g., flammable, toxic, radioactive).

### Temporary Storage:

Waste is stored in safe, leak-resistant containers with clear warning labels.



### Treatment:

Waste is treated to reduce its toxicity or convert it into less hazardous materials using acids or bases and oxidation or reduction processes.



### Final Disposal: This includes:

- **Landfill Disposal:** Waste is buried in specially designed landfills with sealing layers.
- **High-Temperature Incineration:** Some waste is burned to reduce its volume and eliminate toxicity.
- **Recycling:** In some cases, chemical solvents can be purified and reused.

### Monitoring and Follow-Up:

Monitoring final disposal sites to ensure no environmental contamination occurs, using techniques like chemical precipitation or filters to remove heavy metals from wastewater.

## Research and Investigation

### Task:

Explore the impact of natural resource depletion by studying the effects of deforestation and mining on the ecosystem.

### Steps:

- 1 Choose an area suffering from deforestation or mining.
- 2 Collect data on biodiversity loss, soil quality, and water quality in the area.
- 3 Compare the results with another area unaffected by human activities.







## Chapter Two

### Lesson 3: Renewable Energy

#### Get Ready!!!

- Imagine you are walking on a sunny day, wishing you could make better use of this renewable energy. Or perhaps you notice the strong winds outside and think about how to convert them into energy.
- In this lesson, we will learn about different types of renewable energy, how to harness them, and assess their impact on the environment and climate. Let's begin exploring these natural energy sources and how to convert them into energy for effective use.

#### Renewable Energy Examples

Renewable energy is energy that naturally replenishes in a short time.



Wind



Solar



Geothermal



Hydro



Biomass



Tidal







## ► First: Solar Energy

### Solar Cells:

These are made of semiconductors that convert solar energy directly into electrical energy and are considered modern means of energy generation.

### Importance:

They help preserve the environment and reduce pollution caused by fossil fuels.

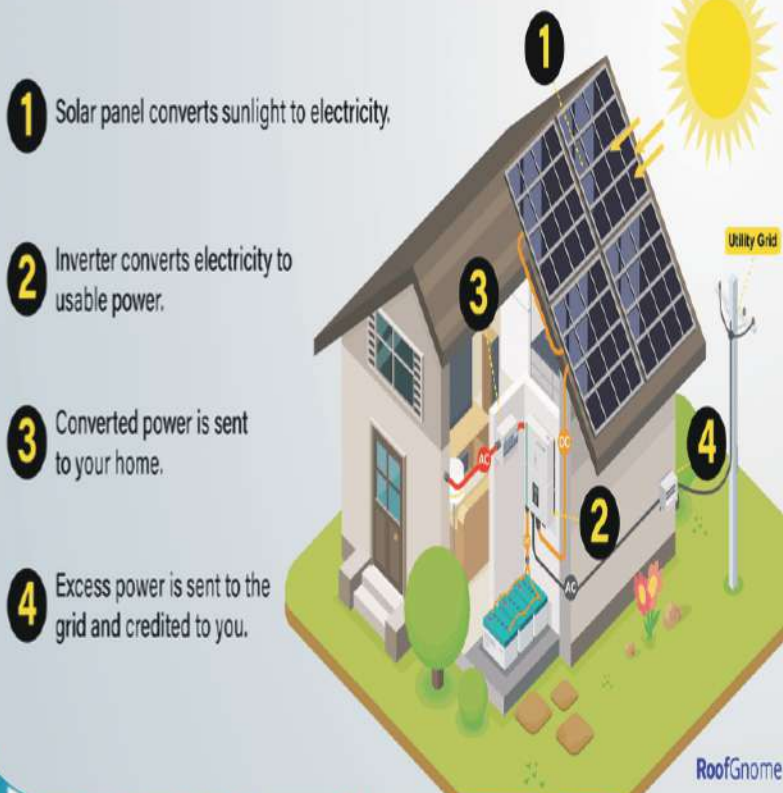
### How They Work:

When light falls on the surface of a semiconductor material like silicon, electrons are displaced to one of the surfaces, creating a voltage difference that can generate an electric current when connected to an external circuit.

### Solar Cell Efficiency:

Efficiency is measured by comparing the generated electrical energy to the incident solar energy.

## How Solar Power Works



## Efficiency Factors

It depends on factors such as the angle of light incidence, clouds, dust, and humidity. It can be improved using technologies like nanotechnology.

### ● Calculating Electrical Energy:

Electrical energy (E) in joules is calculated using the formula:

$$E = V \times I \times t$$







- Where **I** is the electric current in amperes (**A**), **V** is the voltage difference in volts (**V**), and **t** is the time the electric current passes in seconds (**s**).
- In practical applications, it is preferred to work with power (**P**), measured in watts (**W**), which represents the energy produced or consumed in one second. It is calculated using the formula:

$$P = I \times V$$

$$\text{Solar cell efficiency} = \frac{\text{Output electrical power}}{\text{Incident optical power on the cell}} \times 100$$

- Example:** A solar panel generates a voltage difference of 10 V, and a current of 0.5 A flows when an electrical circuit is connected to it. Calculate the electrical power it produces.

## Solution

### Think:

If you have a solar cell installed on the roof of your house, and this solar cell operates at an efficiency of %20, meaning it converts 20% of the solar energy it receives into electrical energy.

- 1 If the sunlight provides 1000 W/m<sup>2</sup> of solar energy on the surface of the cell, what is the amount of electrical energy produced by the solar cell per square meter?
- 2 If the area of the solar cell is 2 m<sup>2</sup>, what is the total electrical power produced by the panels?
- 3 How can the electrical power output from solar cells be increased?
- 4 If the area of the solar cell is 2 m<sup>2</sup>, what is the total electrical power produced

## Second: Wind Energy

- Wind energy relies on converting the movement of air into clean electrical energy using wind turbines, which consist of slanted blades, turbines, and electrical generators.







## How it works:

The blades attached to the turbines generate mechanical movement when air passes through them, which is then converted into electrical energy by the generators.

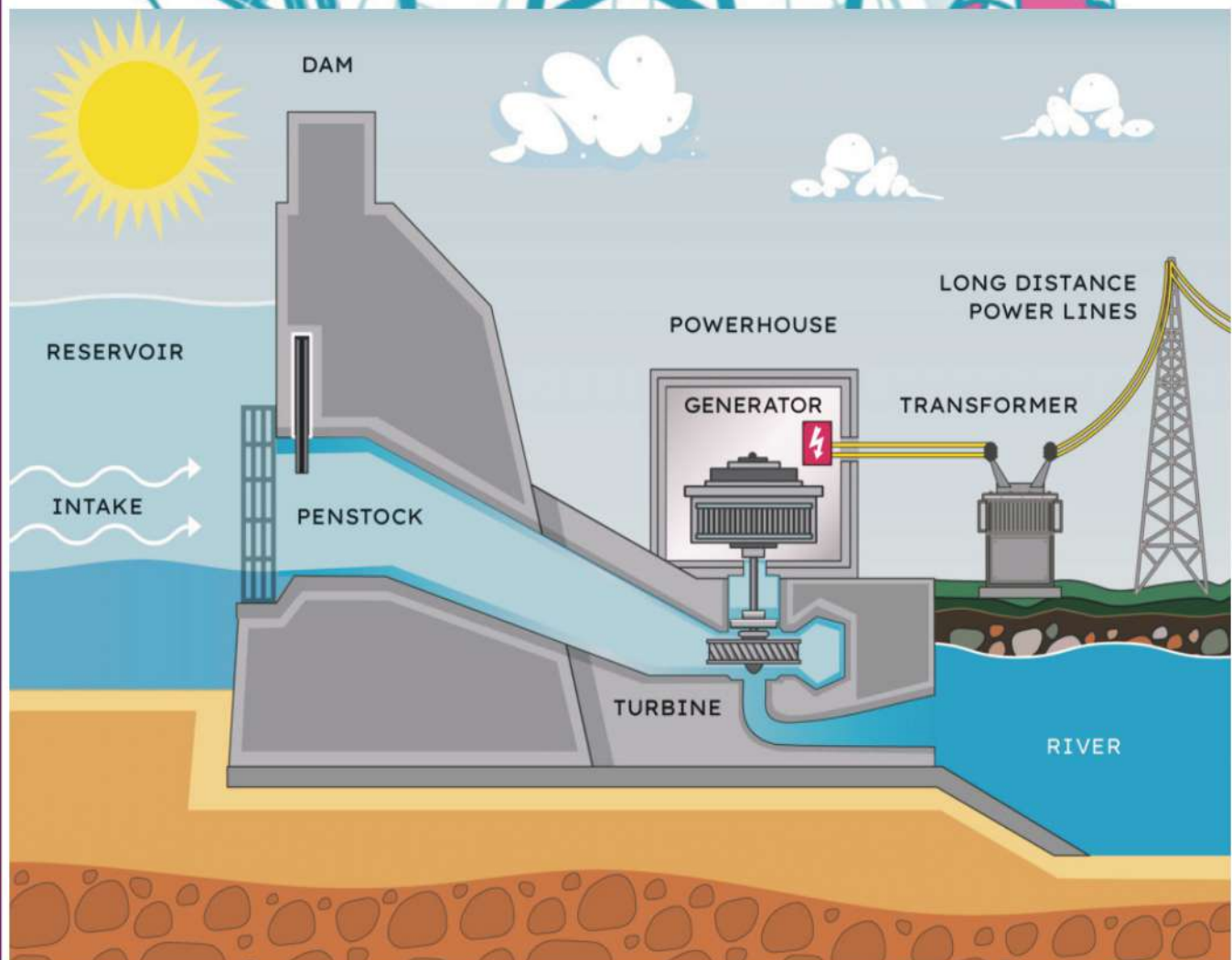
## Location of turbines:

It is preferable to build turbines in open areas like deserts and elevated regions (Why?) to increase efficiency due to higher wind speeds.

## Third: Hydropower Energy

This relies on using dams to store water, which gains potential energy. The dams have gates that control the flow of water from the top to the bottom.

## How it works:







## ► Fourth: Biomass Energy

- Biomass energy is produced from organic materials such as plants and animals, and is converted into biofuels (like ethanol and biodiesel) or electricity through combustion.

### Example:

- Crops like corn and sugarcane are used to produce ethanol, a fuel that serves as an alternative to gasoline.
- Crop residues and agricultural waste can be used to generate energy through fermentation or combustion.
- Biomass energy helps reduce carbon emissions compared to fossil fuels, as the carbon released during the combustion of biomass fuel was previously absorbed from the atmosphere by plants.



### Research Activity

Research the impacts of renewable energy on the environment and climate change.

### Scientific Activity

- Conduct a simple experiment using small solar cells to measure the amount of electricity that can be generated from sunlight at different times of the day.
- Record the results and analyze them to determine the best times to take advantage of solar energy.







## Chapter Two

### Lesson 4: Applications of Renewable Energy in Daily Life

#### Get Ready!!!

Have you ever wondered how using renewable energy impacts your daily life? Perhaps you have noticed solar panels on rooftops or seen wind turbines spinning at wind farms. **In this lesson**, we'll explore how renewable energy is converted into electricity and how it's used in our everyday lives. We will analyze the effectiveness of these technologies in reducing carbon emissions and examine their environmental impact through chemical interactions.

### Using Living Organisms to Produce Renewable and Sustainable Energy

#### Green Biotechnology: An Innovative Field Combining Biology and Technology

The use of living organisms to produce renewable energy is an innovative field that merges biology and technology to create sustainable energy sources. This field leverages the natural biological processes occurring in living organisms.

#### Enhancing the Use of Natural Resources

Research and development in this area contribute to maximizing the use of natural resources in ways that preserve the environment and support global energy goals.

#### Using Biomass for Energy Production

- Agricultural waste, such as rice straw, or specific plants, like sugarcane, can be used to produce energy.
- These processes involve fermentation and anaerobic decomposition, helping to reduce reliance on fossil fuels.







## New Opportunities from Microalgae and Microorganisms

Microalgae and microorganisms offer new opportunities for producing biofuels through advanced biological processes, such as converting organic materials into electrical energy or liquid fuel.

### Introduction to Renewable Energy from Living Organisms

The use of living organisms to produce renewable energy is an innovative field that combines biology and technology to create sustainable energy sources.

This type of energy relies on utilizing the natural biological processes occurring in living organisms. Research and development in this field enhance our ability to use natural resources in an environmentally friendly way while supporting global energy goals.

#### 1 Sources of Energy from Living Organisms:

- **Biomass:** Agricultural waste, such as rice straw, or specific plants like sugarcane, can be used to produce energy through processes like fermentation and anaerobic decomposition, reducing reliance on fossil fuels.
- **Microalgae and Microorganisms:** Microalgae and microorganisms offer new opportunities for producing biofuels through advanced biological processes, such as converting organic materials into electrical energy or liquid fuel.

#### 2 Types of Organisms Used in Energy Production

- **Methane-Producing Bacteria:** These bacteria can break down organic materials in waste treatment plants or livestock farms, producing methane as a biofuel.
- **Enzymes:** Enzyme-based energy is an innovative development in renewable energy. Enzymes can convert plant cellulose into sugars that can then be transformed into ethanol. They can also facilitate the conversion of fats into biodiesel using specific enzymes.
- **Microalgae:** Microalgae are considered a promising future solution for biofuel production. They can be cultivated in controlled environments to produce oils that are converted into biodiesel.







## 3 Other Biological Sources of Energy

- **Energy from Plants:** Plants can be converted into biofuels through processes like fermentation and decomposition to meet energy needs. Aquatic plants, such as water hyacinth and algae, are used to produce biodiesel or ethanol.
- **Marine Algae:** Marine algae, which grow rapidly in saltwater, can be used to produce biofuels without requiring agricultural land.
- **Phototrophic Bacteria:** Phototrophic bacteria utilize light to convert carbon dioxide and water into biofuels, such as ethanol or hydrogen.



Aquatic plants



Marine Algae



Phototrophic Bacteria

## Examples of Household Devices Powered by Solar Energy

### Solar Water Heaters:

Solar water heaters are used to heat water at home, reducing reliance on electric heaters and helping save electricity.



### Solar-Powered Air Conditioners:

Solar-powered air conditioners are suitable for hot regions, as they help reduce electricity consumption in homes.



### Solar Lamps:

These lamps are used to illuminate and decorate gardens and serve as an alternative to traditional lighting during power outages. They are environmentally friendly.





# Chapter 3: Patterns of resource recycling and utilization



In this chapter, we will study the following topics:

1

**Patterns of Resource Recycling and Utilization**



2

**Resource Recycling Techniques and Their Impact on the Environment**



3

**Green Hydrogen as a Clean Fuel**







## Chapter Three

### Lesson 1: Patterns of Resource Recycling and Utilization

#### Get Ready!!!

- Resource Recycling is the process of reusing materials that have already been used, transforming them into new products instead of discarding them as waste.
- This process plays a vital role in achieving sustainable development by reducing the pressure on natural resources and minimizing environmental pollution. Let's explore some methods of resource recycling and their benefits to the ecosystem.

### Methods of Resource Recycling and Their Benefits to the Ecosystem

#### 1 Mechanical Recycling

This is the most common method worldwide. It involves collecting non-degradable material residues and reintroducing them into the same industry to go through the same manufacturing processes again, resulting in a product of the same type.



#### 2 Energy Recycling

This method is used for plastic residues, where they are converted into electrical or thermal energy through combustion, transforming the plastic into fuel.

**Example:** Recycling aluminum saves about 95% of the energy required to produce aluminum from bauxite.



- The recycling process takes place in electrolysis cells, which demand high electrical energy. In contrast, recycling involves simply melting down consumed aluminum and reshaping it, requiring significantly less energy.







## Note:

Despite the significant benefits of energy recycling, it is important to consider its negative aspects, such as air pollution resulting from waste burning. Therefore, more sustainable technologies must be developed.

**Example:** If producing one ton of aluminum from raw materials requires 15,000 kilowatt-hours, recycling the same amount requires only 750 kilowatt-hours.

## Solution

### Calculating Saved Energy

**Saved Energy = Energy Used in Original Production - Energy Used in Recycling**

## 3 Chemical Recycling

This method involves using chemicals added to waste to recover basic materials or to break down biological residues for producing biogas.

### a Thermal Decomposition:

A chemical process conducted at high temperatures in the absence of oxygen, where organic waste is broken down into simpler components, such as gas, low-density liquids like bio-oils, and solid materials.

### Examples:

**E-Waste Decomposition:** Chemicals such as acids are used to separate valuable metals like gold and copper from electronic waste.

**Expired Drug Decomposition:** Acids or bases are used to break down old medicines into harmless compounds.







## b Chemical Sterilization:

This involves chemical reactions to neutralize toxic or harmful substances in waste, such as:

- **Neutralizing reaction:** In chemical waste, acids or bases can be neutralized with counter substances like sodium carbonate or sodium hydroxide.

**Example:** The reaction of hydrochloric acid with sodium hydroxide produces salt and water.

- **Medical Waste Treatment:** Chemicals like chlorine or ozone are used to treat medical waste, eliminating bacteria and viruses.

## 4 Biochemical Interaction

This method uses living organisms or enzymes to convert organic waste into usable materials, such as turning organic waste into compost.

**Examples:**

- **Biological Decomposition:** Organic waste, such as food leftovers, can be transformed into organic compost through chemical reactions facilitated by microorganisms.
- **Converting Waste into Biofuel:** Specific bacteria can convert organic waste into biofuels such as ethanol.

## The Impact of Recycling on Maintaining Environmental Balance

- 1 Recycling One Ton of Paper:** Recycling a single ton of paper saves 17 trees, %70 of the energy, and 85% of the water required to produce new paper.
- 2 Environmental Impact:** By recycling all newspaper paper, we can reduce carbon dioxide emissions by 20 million tons annually—equivalent to removing 5 million cars from the roads.

## Research and Exploration: The Sustainable City of the Future

By 2050, imagine living in a city entirely reliant on renewable energy sources and advanced recycling technologies. This city serves as a model for environmental conservation and sustainable resource utilization. Its key features include:







## 1. Dependence on Renewable Energy:

The city meets all its energy needs through renewable sources like solar, wind, and geothermal energy.

## 2. Advanced Resource Recycling:

All waste is transformed into reusable materials through advanced chemical and physical technologies. No waste is sent to landfills; everything is recycled to create new products.

## 3. Chemical Recycling Technologies:

Factories employ chemical recycling technologies to convert plastics, metals, and glass into new materials. These technologies reduce the depletion of natural resources and minimize environmental pollution.

## Challenges and Opportunities

- **The Biggest Challenge:** Plastic Waste: Plastics pose a significant challenge due to their difficulty in decomposing naturally. Using innovative technologies to chemically break down plastics, they can be converted into basic components for new, reusable materials.
- **The Role of Research and Development:** You are part of a research team specializing in evaluating the efficiency of chemical recycling techniques for plastics compared to traditional methods. The team is also working on developing new methods to enhance the recycling processes for aluminum and glass using these technologies.

## Key Discussion Points

1

### Environmental and Resource

**Conservation:** Recycling helps reduce excessive consumption of natural resources, thereby preserving habitats and ecosystems.

### 2 Reduction in Resource

**Extraction:** Recycling reduces the need for resource extraction, thereby mitigating the environmental impacts of mining and deforestation.

3

### Reduction in Environmental

**Pollution:** Recycling lowers environmental pollution, which can negatively impact wildlife and surrounding ecosystems.







## Chapter Three

### Lesson 2: Resource Recycling Techniques and Their Impact on the Environment

#### Get Ready!!!

- Imagine you have a box filled with a mixture of different materials like iron, plastic, and glass. How can you separate these materials and recover each one for reuse?
- In this lesson, we will explore modern techniques used in resource recycling and how these techniques impact the environment. We will learn about methods such as magnetic separation and electrostatic separation, as well as how chemical reactions contribute to material reprocessing. Let's embark on this journey into the world of technologies that help preserve our planet.

### Modern Techniques in Resource Recycling

Modern resource recycling techniques rely on advanced chemical and physical processes to transform waste into reusable materials, reducing the depletion of natural resources and minimizing environmental pollution. These techniques promote sustainability and contribute to a circular economy.

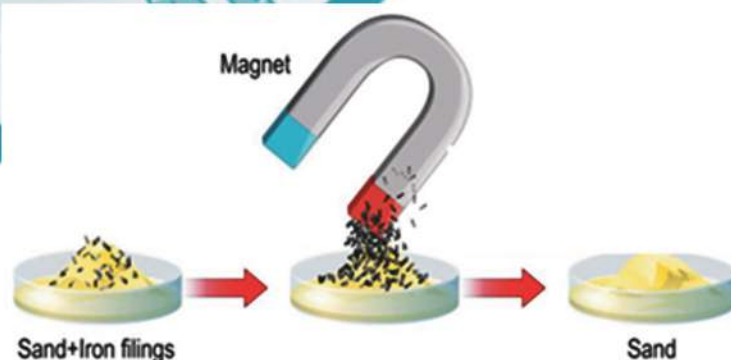
#### 1 Magnetic Separation

##### Definition:

Magnetic separation relies on the use of a strong electromagnet to separate magnetic materials from other substances.

##### Working Mechanism:

An electric current is passed through a copper coil wrapped around a soft iron core, turning the core into a temporary magnet that attracts surrounding magnetic materials.





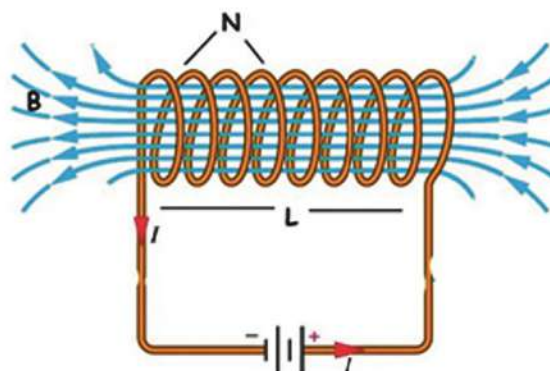


## Calculating Magnetic Flux Density

$$\therefore B = \frac{\mu N I}{L}$$

### Where:

- B: Magnetic field density (Tesla)
- N: Number of turns in the coil
- I: Electric current (Amperes, A)
- r: Radius of the coil (meters, m)
- L: Length of the solenoid (meters, m)
- $\mu$ : Magnetic permeability (T.m/AT)



- **Example:** A solenoid with a length of 3.2 cm consists of 90 turns. A constant current of 1.2 A flows through the wire. Calculate the magnetic flux density at the center of the solenoid.

### Solution



## Applications of Magnetic Separation and Its Role in Energy Recycling

### A) Recycling:

Separating metals from waste based on their magnetic properties.

### B) Environmental Cleaning:

Removing magnetic pollutants from water and soil.

### C) Food and Pharmaceutical Industries:

Ensuring product purity.

### D) Mining:

Extracting metals from raw ores.







**E) Chemical and Petrochemical Industries:** Purifying raw materials and removing impurities.

**F) Electronics:** Recovering precious metals from electronic waste.

**G) Automobile Industry:** Separating iron and steel from old cars to facilitate recycling.

## 2 Electrostatic Separation

### Introduction:

Static electricity is a physical phenomenon caused by an imbalance of electric charges within or on the surface of a material. When a material loses electrons (negatively charged particles), it becomes positively charged, and vice versa. This charge remains stationary until a discharge occurs.

### How is static electricity generated?

Static electricity can result from several factors, including:

- a) Friction:** When two objects are rubbed together, electrons transfer from one to the other, charging both objects oppositely (e.g., rubbing a balloon on hair).
- b) Contact:** When a charged object touches a neutral one, electrons transfer between them, charging the neutral object.
- c) Induction:** When a charged object is brought near a conductor, charges redistribute in the conductor, with opposite charges gathering near the charged object.



### Examples of Static Electricity in Everyday Life:

- a) Electric shock when touching a metal doorknob:** Caused by charge buildup on the body due to friction with clothing.
- b) Hair attracted to a plastic comb after brushing:** Due to electron transfer from hair to the comb.
- c) Balloon sticking to a wall after being rubbed on hair:** Due to electrostatic attraction between opposite charges.







### Mechanism of Electrostatic Separation:

- Electrostatic separation involves exposing a mixture of particles to an electric field, which charges particles differently based on their properties.
- Charged rods with opposite charges repel particles of the same charge and attract particles of the opposite charge, enabling separation.

## Advantages and Disadvantages of Electrostatic Separation

### Advantages:

Allows separation of large mixtures of materials with similar shapes and sizes but different electrical properties.

### Disadvantages:

Requires precise control of electrical current, humidity, and temperature, as these factors significantly impact the process.

### Examples of Materials That Can Be Separated:

- Plastics and Metals:** Separate plastics like polyethylene from metals like aluminum in an electric field.
- Plastics and Glass:** Separate plastics such as PVC from glass.
- Wheat and Metallic Impurities:** Separate grains like wheat from metallic contaminants.

## 3 Thermal Recycling

### Definition:

A process of reusing materials by heating solid or liquid waste to high temperatures to extract energy or convert them into reusable materials.

### Examples of Thermal Recycling:

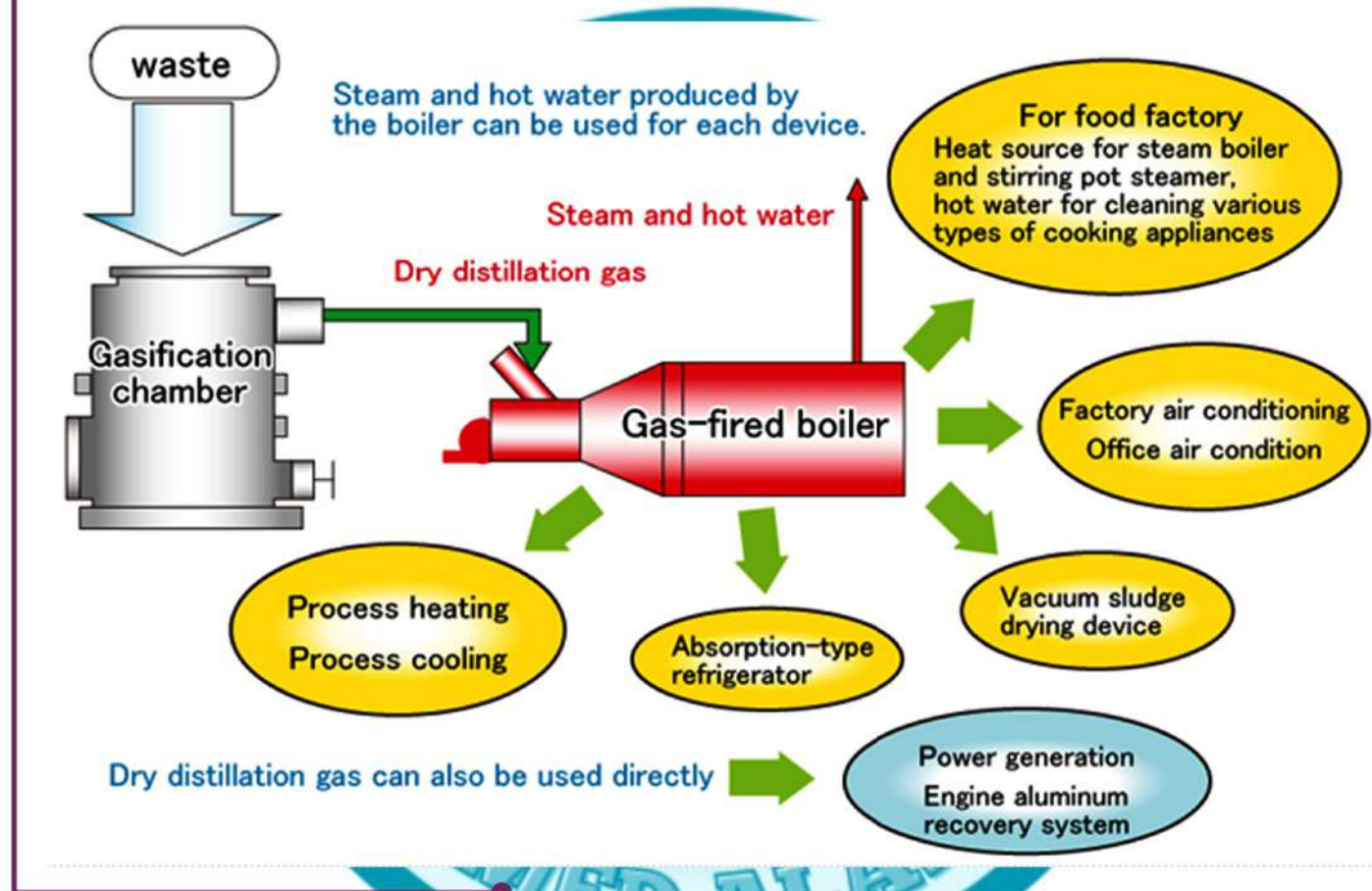
- Thermal Plastic Recycling:** Heating certain plastics, such as PET, and reshaping them into new products.







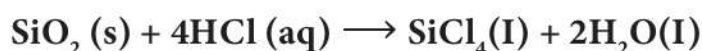
- b Thermal Rubber Recycling:** Reusing old tires by reshaping them through heating for use in asphalt production or other rubber products.
- c Pyrolysis of Waste:** Heating certain wastes, such as organic and plastic waste, in the absence of oxygen to break them down into gases, liquids, and charcoal.
- d Waste Incineration for Energy Generation:** Burning waste to generate electricity or heat, reducing waste and recovering energy. However, this requires measures to reduce harmful emissions.



## Chemical Analysis and Reprocessing

**Definition:** A process where materials are broken down into their basic components using chemical reactions, such as crushing and melting glass in special furnaces to produce new glass.

**Example of Chemical Analysis:** Reaction of silica ( $\text{SiO}_2$ ) with hydrochloric acid ( $\text{HCl}$ ) to produce silicon tetrachloride ( $\text{SiCl}_4$ ) and water.







## Assessing Ecosystem Health

Recycling technologies help reduce the need to extract new resources, minimizing the environmental impact of mining, reducing landfill waste, and contributing to the preservation of ecosystem health and biodiversity.

## Research and Investigation

**Comparison of Material Recycling Techniques:** Conduct comprehensive research on various techniques like magnetic separation and electrostatic separation.

### Research Focus:

- Understand how each technique works and the materials it can separate.
- Examine the environmental impact of each technique, such as energy consumption, resulting waste, and gas emissions.

### Comparison Table Template:

Technique	Environmental Efficiency	Advantages	Examples of Materials Separated	Disadvantages
Magnetic Separation			Ferrous metals (e.g., iron)	
Electrostatic Separation			Plastics and metals	
Density-Based Separation			Materials separable by density	
Lightweight and Heavy Material Separation			Lightweight and heavy materials	







## Chapter Three

### Lesson 3: Green Hydrogen as a Clean Fuel

#### Get Ready!!!

Imagine a future where we use an eco-friendly fuel that helps reduce climate change. In this lesson, we will explore green hydrogen as a clean and efficient fuel that could be a potential alternative to fossil fuels. We will learn how green hydrogen is produced, how it can replace conventional fuels, and its positive impact on the environment. Imagine how the world would be if green hydrogen became the primary source of energy!

#### Learn

- In light of increasing environmental challenges, green hydrogen is a promising clean fuel, yet its large-scale and efficient production faces difficulties.
- Organisms like bacteria and algae play an important role in this field, as they can produce hydrogen through natural biological processes. These biological methods are highly efficient and have a lower environmental impact compared to traditional methods.
- These organisms rely on light or organic materials to produce hydrogen, making them a promising option for sustainable energy. Therefore, investing in research and development in this field will contribute to achieving sustainable development goals and reducing reliance on conventional energy sources.

#### Green Hydrogen Production Process

- The efforts of governments to heavily invest in green hydrogen production face several challenges. These include high production costs, limited **renewable energy**, and **storage difficulties**.
- Progress in this field can be made by transitioning from gray and blue hydrogen to green hydrogen.
- Hydrogen itself has no true color, as it is a colorless gas, but colors are used as terms to indicate the method of its production:
  - o **Green Hydrogen:** Considered the purest type, it is characterized by zero environmental emissions (zero carbon). It can be directly used as fuel for cars due to its high quality.

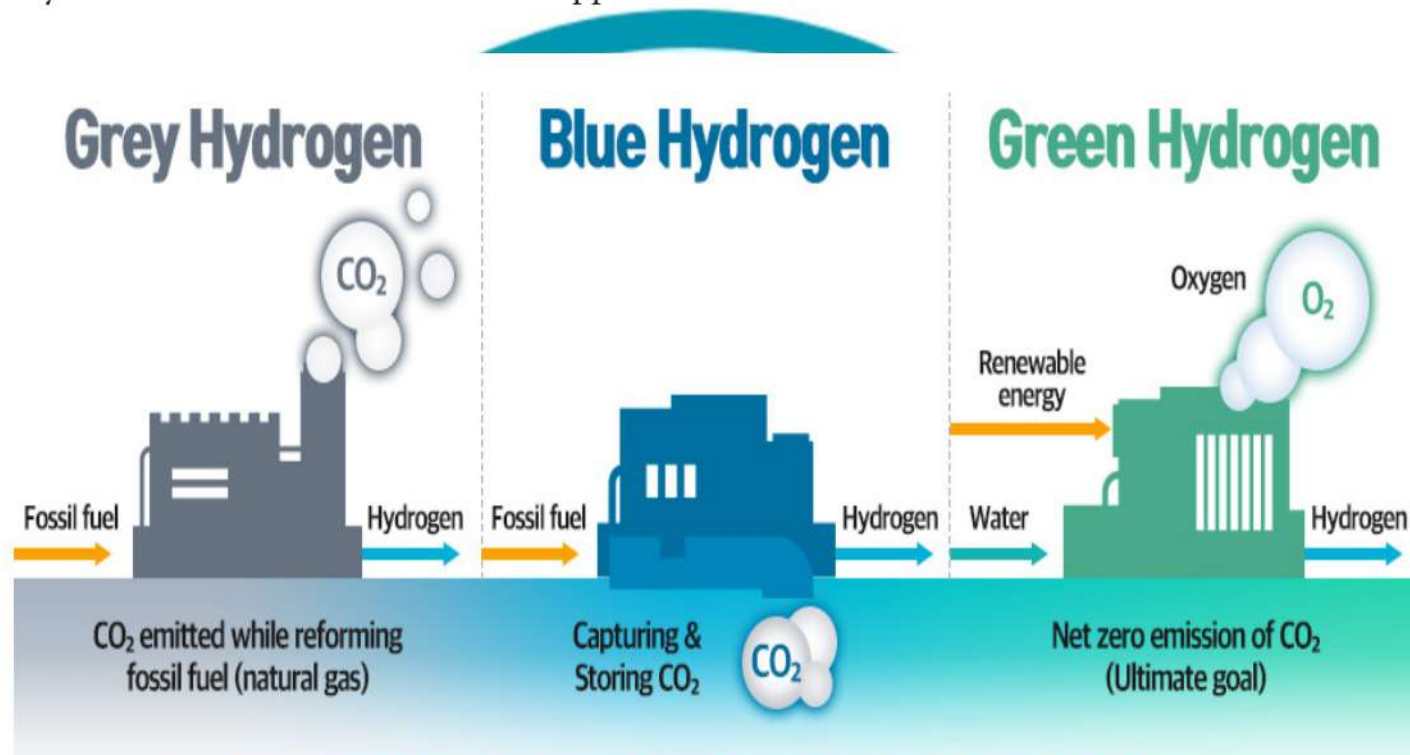






● **Blue Hydrogen:** Less pure, as it involves %10 carbon emissions, and is used in industrial activities.

● **Gray Hydrogen:** Produced using traditional methods that generate carbon emissions. Green hydrogen remains the most expensive. This is because producing one ton of green hydrogen requires 61 megawatt-hours of renewable electricity. Therefore, to replace the currently produced gray hydrogen with green hydrogen, it would require 36,000 megawatts, which is more than 60% of Egypt's total electricity generation capacity, according to a study by the Information and Decision Support Center.



## Challenges in Storing Green Hydrogen

- Renewable energy production is not the only challenge facing green hydrogen production; **there is also the challenge of storing it before consumption or transportation.** Various options exist for storing hydrogen, such as storage in salt caverns or depleted gas fields.
- **In Egypt,** depleted gas fields can be used for hydrogen storage in areas such as the Nile Delta and the Western Desert. However, there is limited information regarding the number of salt caverns used for this purpose.
- Additionally, there could be a problem with hydrogen reacting with remaining materials in depleted wells, potentially leading to the release of hydrogen sulfide gas.

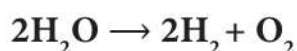




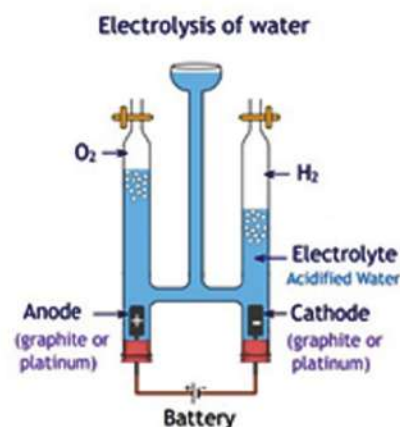


## Green Hydrogen Production

- Green hydrogen can be produced through the process of water electrolysis, where an electric current is passed through water to break it down into hydrogen and oxygen.



- For hydrogen to be considered «green,» the electricity used in the electrolysis must be carbon-free (green electricity), meaning it is produced from renewable energy sources such as water, wind, or solar power.



## Biological Methods for Hydrogen Production

- Green hydrogen can also be produced through biological methods using:
  - a. Bacteria:** Certain types, such as Clostridium and Enterobacter, can produce hydrogen by breaking down organic materials in the absence of oxygen.



### Hydrogen Production Mechanism

The hydrogen production mechanism by Clostridium and Enterobacter follows a series of basic steps:

- 1 Primary Breakdown of Organic Materials:** Bacteria break down complex organic compounds into simpler components.
- 2 Fermentation:** The simple components are converted into organic acids like formic acid and lactic acid, which are then converted into hydrogen gas and carbon dioxide.
- 3 Enzymatic Reactions:** The bacteria use specific enzymes to catalyze reactions that produce hydrogen.







## Factors Affecting Hydrogen Production

Hydrogen production depends on several factors, including:

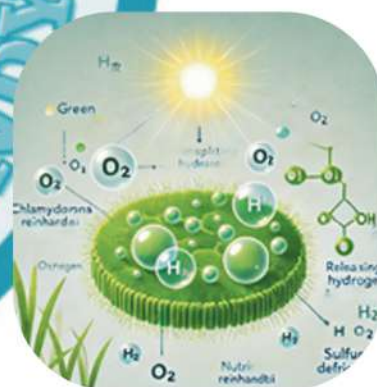
- 1 **Temperature:** Clostridium bacteria require temperatures between 60-30 °C, while Enterobacter can grow at lower temperatures.
- 2 **pH:** Both bacteria require a specific pH range, often around 7-6, for efficient hydrogen production.
- 3 **Type of Organic Material:** Carbohydrates are the optimal material for stimulating hydrogen production, while proteins may produce unwanted gases.
- 4 **Algae:** Species like Chlamydomonas reinhardtii can produce hydrogen using solar energy during photosynthesis. Under certain conditions (such as sulfur deprivation), algae can convert water into hydrogen and oxygen.

● To illustrate how algae produce hydrogen during photosynthesis, we can represent this process with the following equations:

- 1 **Basic Water Splitting Equation:** In this process, algae split water into hydrogen gas (2H<sub>2</sub>) and oxygen gas (2O<sub>2</sub>) using solar energy.



- 2 **Traditional Photosynthesis (Under Normal Conditions):**  
Under normal conditions, algae produce oxygen through photosynthesis: Oxygen, hydrogen ions, and electrons are generated in the process.



- 3 **Hydrogen Production Under Sulfur Deprivation:** When sulfur is deficient, algae convert electrons from water splitting to produce hydrogen instead of oxygen: In this case, the electrons and hydrogen ions generated are used directly to produce hydrogen gas.



● These equations show how algae harness solar energy to produce hydrogen, a clean and sustainable energy source.







## Applications of Green Hydrogen in Clean Energy Technologies

### 1 Transportation

- **Hydrogen Cars:** Fuel cells convert hydrogen into electrical energy, reducing the use of fossil fuels and lowering carbon emissions.
- **Public Transport:** Many cities have started using hydrogen-powered buses, supporting the shift towards eco-friendly transportation.



### 2 Industry

- **Industrial Processes:** Green hydrogen can replace natural gas in various industrial processes.
- **Efficiency Improvement:** Hydrogen helps reduce carbon emissions from heavy industries, supporting environmental sustainability.



### 3 Air Quality Improvement

- **Pollutant Reduction:** Using green hydrogen helps decrease airborne pollutants, leading to improved air quality in cities.

#### Did you know?

The biological production of green hydrogen faces several challenges, including:

- Low efficiency and high costs associated with research, development, and operation.
- The need for precise environmental conditions and sustainable food sources for the organisms used.
- Challenges related to the stability of the organisms and integration with existing industrial processes.
- Despite these challenges, investing in this field is essential to achieving a sustainable energy future.







## Research and Investigation: Green Hydrogen vs. Fossil Fuels

Imagine a world where cars drive, airplanes fly, and factories operate using clean energy that doesn't harm the environment. This world may not be far off, thanks to renewable energy and innovative technologies like green hydrogen.

### ● Fossil Fuels: The Past and Environmental Risks

The world still heavily relies on fossil fuels (oil, coal, natural gas), which require complex extraction processes like drilling and mining. The major issue is that burning fossil fuels releases large amounts of carbon dioxide (CO<sub>2</sub>) and other pollutants, contributing to climate change and air pollution.

### ● Comparison Between Green Hydrogen and Fossil Fuels

- **Green Hydrogen:** Used to power electric cars, heavy industries, and even airplanes.
- **Fossil Fuels:** Used in most sectors, from car engines to electricity generation.

### ● Comparison Table: Fossil Fuels vs. Green Hydrogen

Fossil Fuels	Green Hydrogen
Requires extraction and refining from underground sources.	Produced from water using renewable electricity.
Affordable energy and easy transportation.	Clean energy with zero carbon emissions.
Causes air pollution and contributes to global warming.	Reduces pollution and improves air quality.
Used in transportation, industry, electricity generation.	Used in transportation, industry, and clean energy.

## Research and Investigation Questions

After filling out the table, answer the following questions based on the information you gathered:

- 1 What is the fundamental difference between the production processes of green hydrogen and fossil fuels?
- 2 What are the main environmental benefits of using green hydrogen compared to fossil fuels?
- 3 Why is green hydrogen considered a sustainable alternative to fossil fuels?
- 4 What are the major challenges facing the widespread use of green hydrogen?
- 5 How can green hydrogen help reduce pollution and climate change?





# Chapter 4: Future of energy



In this chapter, we will study the following topics:

**1 Biotechnology in Energy Development**

66

**2 Applications of Nanotechnology in Energy**

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**3 Technological Innovation in Clean Energy Production**

73





## Chapter Four

### Lesson 1: Biotechnology in Energy Development

#### Get Ready!!!

- Imagine you're part of a team working on developing a new energy source using biotechnology. In this lesson, you will learn how biotechnology can be used to enhance energy sources such as biomass and energy-generating microbes.
- How can these technologies contribute to the development of new and sustainable energy sources, and how do they affect energy efficiency and environmental protection? Let's begin by exploring how biotechnology transforms living organisms into innovative energy sources.

### Biotechnology and the Transformation of Living Organisms into Energy Sources

Biotechnology is a scientific field that deals with using living organisms or their components to achieve specific goals. This field includes applications in medicine, agriculture, and industry, with one of the innovative applications being the use of biotechnology to transform living organisms into energy sources.

#### 1 Bioenergy:

Bioenergy is energy derived from living organisms (plants and animals), and it is characterized by being renewable and environmentally friendly.

#### How living organisms are used to produce energy:

**Biological Decomposition:** Biological decomposition is the process of converting organic materials (such as waste) into energy using living organisms such as bacteria. This process can occur naturally or be artificially controlled in facilities that convert waste into energy. This process often produces methane gas, which can be used as an energy source.







## Basic Steps of Biological Decomposition:

### Hydrolysis:

In this stage, bacteria break down complex organic materials such as carbohydrates, proteins, and fats into simpler units like sugars, amino acids, and fatty acids. **For example, starch (a carbohydrate) is broken down into glucose.**



### Acid Fermentation:

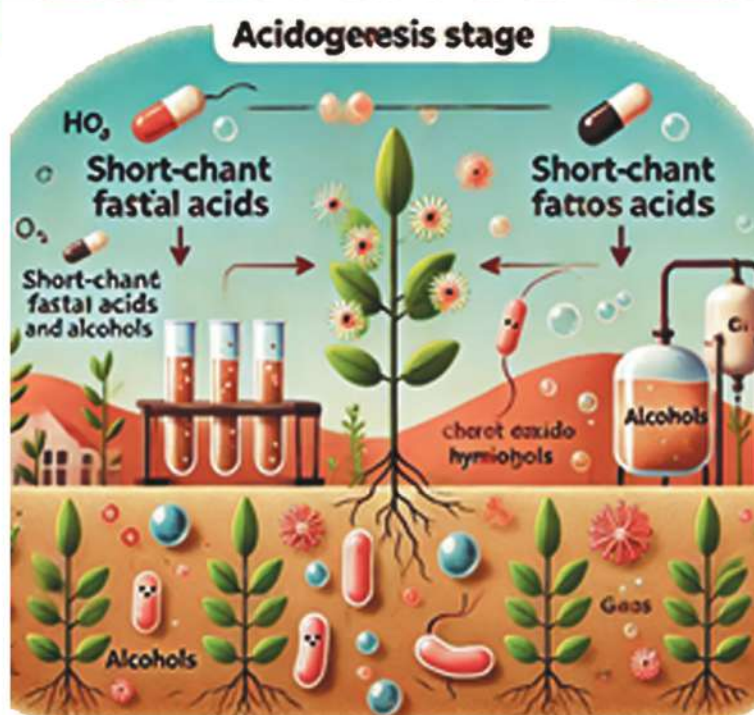
In this stage, acid bacteria convert the sugars and amino acids produced in the initial decomposition into short-chain fatty acids or alcohols. Gases such as carbon dioxide and hydrogen are also produced.

### Acetic Acid Production :

In this stage, bacteria convert the fatty acids, alcohols, or gases produced in the previous stage into acetic acid, hydrogen, and carbon dioxide.

### Methane Production :

In the final stage, methanogenic bacteria convert acetic acid or carbon dioxide and hydrogen into methane gas ( $CH_4$ ) and water. This is the most important stage in the production of biogas energy.







## 2 Biofuel

- Biofuel is a type of energy source produced from living organisms such as plants or algae.
- Biofuels include ethanol and biodiesel. The chemical processes for producing biofuel:

### a Bioethanol Production (Fermentation):

Bioethanol production starts with converting starchy or sugary materials into simple sugars (such as glucose) through hydrolysis. These sugars are then fermented using yeast to produce ethanol ( $C_2H_5OH$ ) and carbon dioxide ( $CO_2$ ).



### b Biodiesel Production:

In this process, vegetable oils or animal fats (which contain triglycerides) react with alcohol (usually methanol or ethanol) in the presence of a catalyst such as sodium hydroxide.

### Search:

Bioenergy is considered an important source of renewable and sustainable energy that relies on the use of renewable natural resources. What are the environmental benefits of using biofuels, and what are the main challenges in using biofuels as an alternative to fossil fuels?.







## Chapter Four

### Lesson 2: Applications of Nanotechnology in Energy

#### Get Ready!!!

Imagine you are working in a modern laboratory where nanotechnology techniques are used to improve energy efficiency and reduce pollution. In this lesson, we will learn how nanotechnology is used in the production and consumption of energy, such as improving the efficiency of solar cells and batteries. We will also discuss the impact of these technologies on the environment and how they can contribute to achieving energy sustainability.

#### Nanotechnology: Its Concept, Applications and Impact on the Future

- **Definition:** Nanotechnology is the science concerned with studying and manipulating materials at the nanoscale, which refers to particle sizes ranging from 1 to 100 nanometers.
- This small size is characterized by unique properties that are completely different from the properties of materials at normal scales. For example, electrical conductivity improves, strength and chemical reactivity increase, and optical properties change.

#### How Does Size Affect Material Properties?

When a material is ground into smaller sizes, its surface area relative to its volume increases, altering its properties. For example, powdered salt dissolves faster than salt cubes because of the increased surface area.

At the nanoscale, material properties change significantly, such as solubility and chemical reactivity.

#### The Importance of Nanotechnology in Energy and the Environment

Nanotechnology is a promising tool for advancing clean energy solutions and protecting the environment by:







- 1 **Enhancing Energy Generation Technologies:** Improving the efficiency of energy production from unconventional sources like solar and wind energy.
- 2 **Reducing Energy Consumption:** By increasing energy production efficiency and providing eco-friendly solutions.
- 3 **Improving Lighting and Heating Effectiveness:** Using nanomaterials with high thermal efficiency for better performance in lighting and heating systems.
- 4 **Increasing Electrical Storage Capacity:** Enhancing battery performance and reducing energy losses.
- 5 **Reducing Pollution:** Contributing to minimizing harmful emissions and purifying water and air.



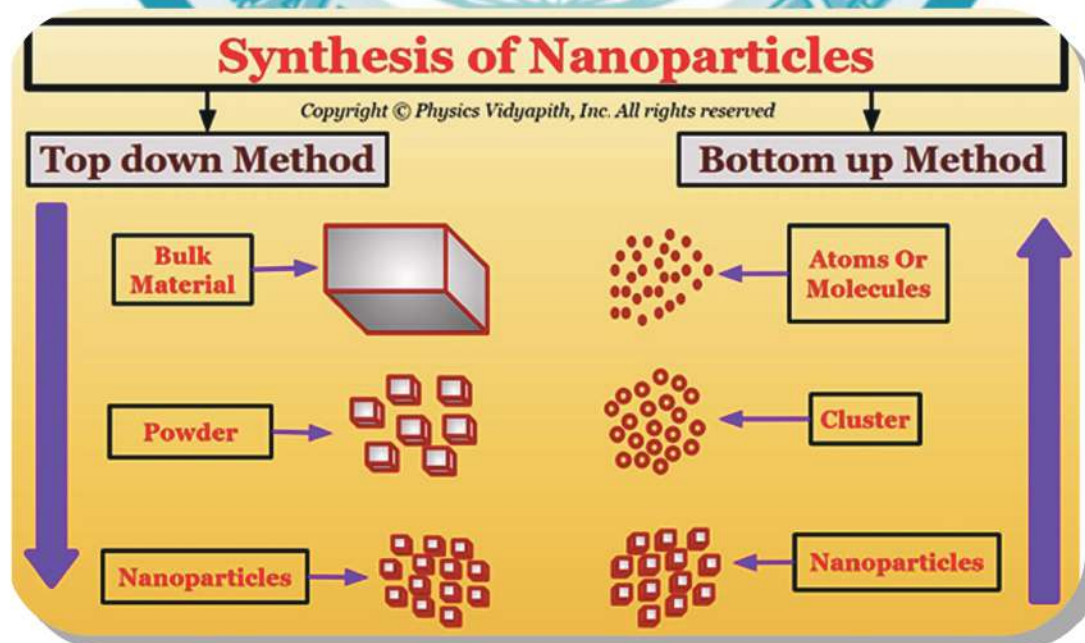
## Methods of Producing Nanomaterials

### 1 Top-to-Down Approach:

This involves reducing the size of a material from its bulk form, similar to sculpting statues or grinding spices.

### 2 Bottom-to-Up Approach:

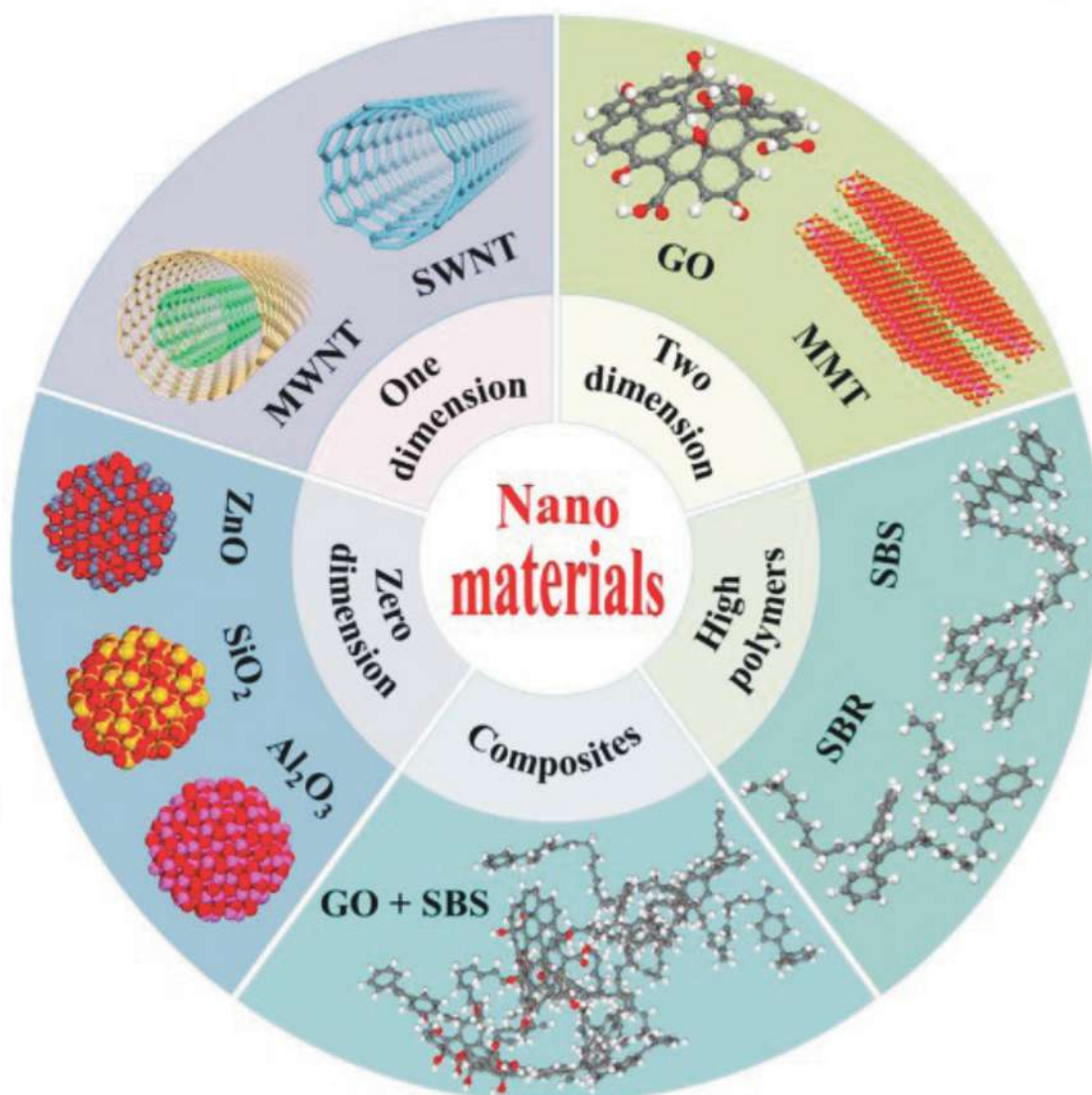
In this method, small molecules are assembled one by one until the desired size is achieved, as in constructing materials from atoms and molecules.



## Nanomaterials classification







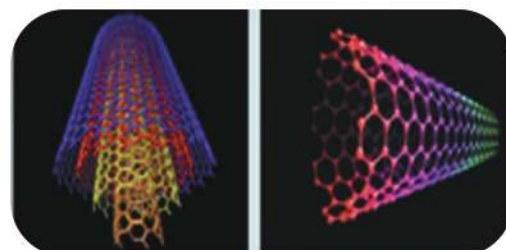
## Examples of Nanotechnology Applications

### 1. Metallic Nanoparticles:

- Gold Nanoparticles: Used to catalyze chemical reactions.
- Platinum Nanoparticles: Play a significant role in fuel cells and help reduce harmful emissions.

### 2. Carbon Nanotubes

Known for their high electrical conductivity, they are used to enhance the performance of electronics, batteries, and energy storage systems.







### 3. Silver Nanoparticles:

Utilized in medical dressings and disinfectant products due to their exceptional antibacterial properties.

## The Impact of Nanotechnology on Battery Improvement

Nanotechnology enhances the performance of batteries, such as lithium-ion batteries, through:

- 1 **Increasing Surface Area:** This improves energy storage efficiency.
- 2 **Enhancing Electrical Conductivity:** Using nanomaterials in the anode and cathode to boost performance and reduce resistance.
- 3 **Reducing Energy Loss:** This extends the battery's lifespan.

## The Role of Nanotechnology in Water and Air Purification

● Nanofillers are used to:

- 1 **Remove Fine Contaminants from Water:** Such as microbes, bacteria, and heavy metals.
- 2 **Provide Effective Solutions:** For protecting the environment and improving public health.

Let your  
light  
Shine







## Chapter Four

### Lesson 3: Technological Innovation in Clean Energy Production

#### Get Ready!!!

- Imagine a world where energy is produced in innovative ways, without polluting the environment and with reduced reliance on traditional resources. Access to clean energy is one of the most important current challenges due to the negative impacts of non-renewable energy (fossil fuels) and the importance of clean energy for the continuation and development of life on Earth.
- In this lesson, we will discuss how modern technology can play a crucial role in producing clean energy.
- Together, we will explore how biotechnology and nanotechnology can help address climate change challenges and achieve energy sustainability.

### Applications of Modern Technology in Clean Energy Production

#### ► First: Advanced Solar Energy Technologies

#### 1 Concentrated Solar Power (CSP)

- The design of concentrated solar power plants focuses on enhancing thermal energy storage, which allows for the production of electricity during periods when the efficiency of solar panels decreases (such as cloudy periods, before sunrise, and after sunset).
- This approach enables the use of solar energy as a sustainable and more efficient source compared to traditional solar panels and fuel-dependent plants.

#### Mechanism of Operation of a Concentrated Solar Power Plant:

- 1 **Mirrors or lenses** are used to focus sunlight onto receivers connected to a network of pipes containing water.
- 2 **Temperature Rise:** The exposure of water to heat converts it into steam.







**3 Energy Conversion:** The steam drives turbines connected to electrical generators, converting kinetic energy into electrical energy.

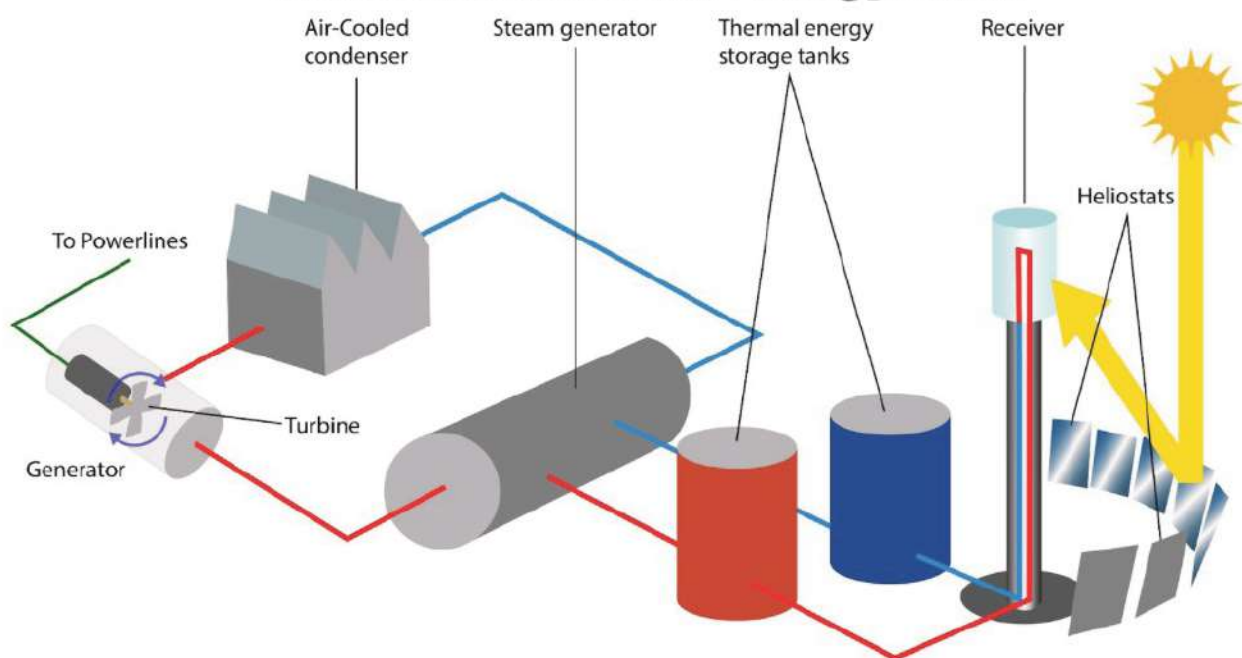
**4 Direct Use or Storage:**

- The heat can be used directly in thermal industries.
- Or it can be stored in insulated cylinders containing molten salt, which retains thermal energy and can be reused for up to 30 years.

## Efficiency Improvement:

- Using reflective materials with high specific heat capacity.
- Applying technologies such as molten salt for heat transfer, increasing the efficiency of converting thermal energy into electrical energy.

## Concentrated Solar Energy Plant



## Research and Investigation

Analyzing Technological Innovation Applications:

### Data Collection:

- Research modern innovations such as nanotechnology and biotechnology.
- Explore how these technologies can be employed to combat climate change and improve clean energy production.







## Final Project

### Title:

Designing a Sustainable Model for Energy and Natural Resource Management in a Local Community

### Context:

- Addressing challenges such as **inefficient energy consumption**, water shortages, and environmental pollution.
- Achieving sustainable development and improving citizens quality of life.

### Project Details:

#### 1 Analyzing the Current Situation:

- Collect information on energy and natural resource usage in the community.
- Identify key problems and analyze their root causes.

#### 2 Exploring Sustainable Solutions:

- Research innovative solutions and best practices to enhance energy and natural resource management.
- Select feasible solutions for local implementation.

#### 3 Designing the Sustainable Model:

- Integrate sustainable solutions into an applicable model.
- Address identified problems effectively.

#### 4 Presenting and Evaluating the Model:

- Test the model to ensure its effectiveness.
- Present it to the local community or an evaluation committee to gather feedback and refine the model.

#### 5 Submitting the Report:

- Prepare a detailed report explaining:
  - The design of the model.
  - How it was implemented.
  - Achieved results.
- Submit the report to the teacher or the local community.







## Key Challenges in the Local Community:

### a Energy:

- Overuse of electricity and inefficient heating/cooling systems.
- Unnecessary lighting.

### b Water:

- Water leaks from old pipes and poor water resource management.
- Pollution of water sources.

### c Pollution:

- Emissions from factories and transportation.
- Improper disposal of industrial waste, contaminating soil and water.

## Final Project

A **sustainable model** that enhances energy and natural resource management, supports sustainability, reduces environmental impact, and improves quality of life.

**MAKE  
today  
GREAT**

